ASTRONOMY

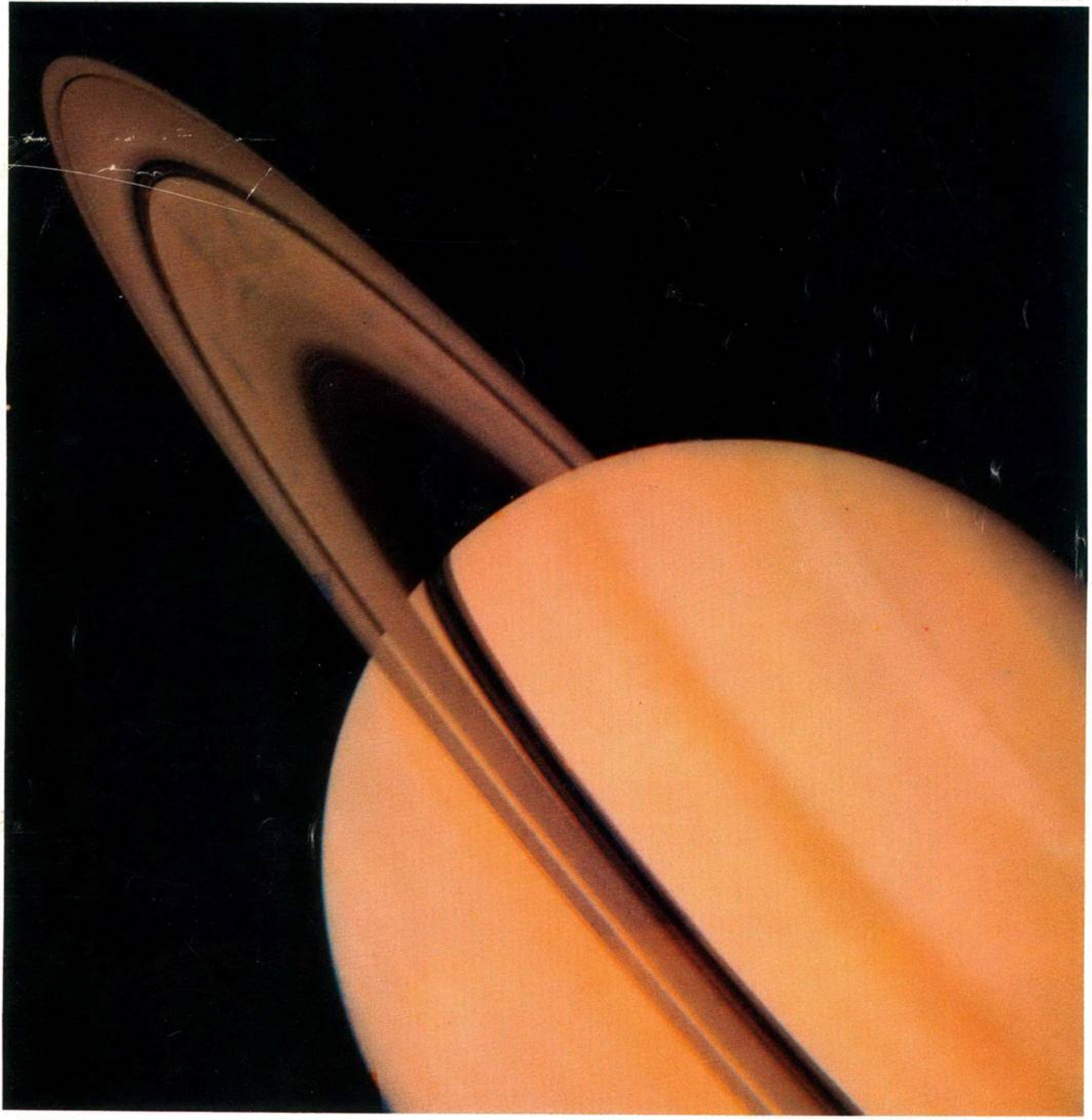
December 1983
U.S. $2
UK £1.15
Can. $2.25

Is There Life on Europa?

Explore the Winter Constellations

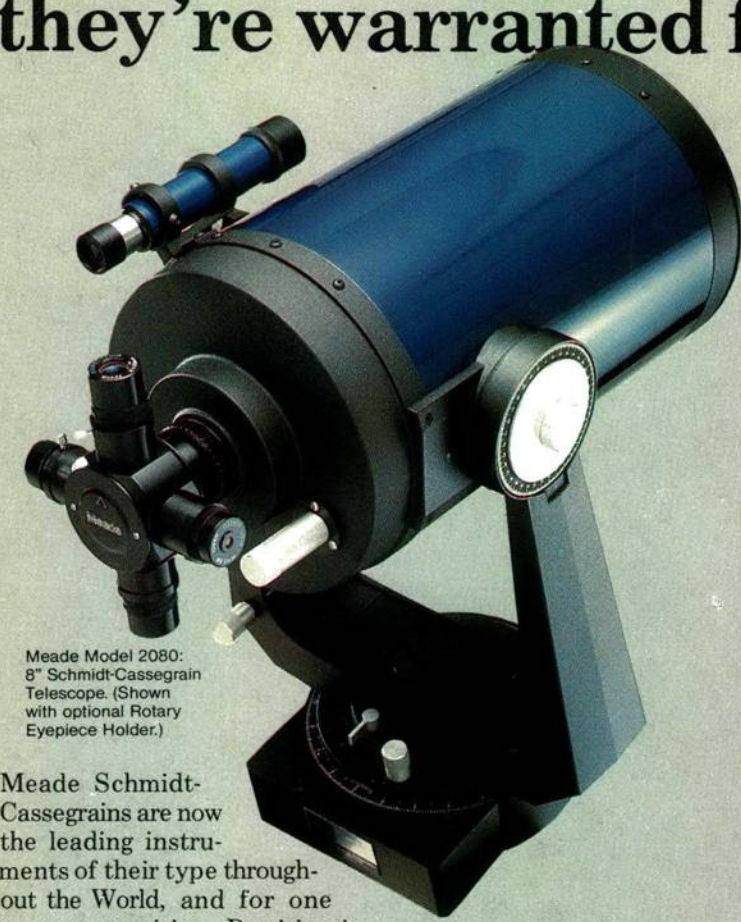
Telescope Control with Microcomputers

ICD# 08070 71574



Will We Go Back to Saturn?

Meade® 4", 8", and 10" Schmidt-Cassegrains: So technically advanced they're warranted for life.



Meade Model 2080:
8" Schmidt-Cassegrain Telescope. (Shown with optional Rotary Eyepiece Holder.)

Meade Schmidt-Cassegrains are now the leading instruments of their type throughout the World, and for one reason: precision. Precision in design, in engineering, and in manufacture. And, now Meade Instruments backs up this commitment to precision with a Warranty **valid for as long as you own your telescope.**

Consider the following technical advantages — advantages that have made Meade Schmidt-Cassegrains Number One worldwide.

Optical Design and Manufacture — Meade 4", 8", and 10" optical system designs utilize the latest, most modern computer-aided ray trace analysis. Analysis which showed us, for example, that by making the primary mirrors of Meade 8" and 10" Schmidt-Cassegrains 3% oversize, we could increase off-axis image brightness by 10% over competing models, aperture for aperture. As a result, the 8" Meade 2080 **without** high transmission coatings yields brighter off-center images than competing 8" telescopes **with** coatings. The 10" Meade 2120 yields off-center images almost as bright as competing 11" models, but with vastly superior portability and at substantially lower cost.

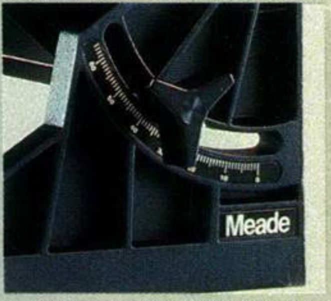
The standard worm-gear drive system of the Meade 8" Model 2080.

Meade diffraction-limited optics are polished to surface accuracies within 1/10-wavelength, and are manufactured and tested with the most precise optical test equipment available. Every 8" system, for example, is tested at 1000X on one of our laser autocollimators and corrected for extremely minute errors in the diffraction image – errors which are invisible to most observers at normal magnifications. Further, each 3-element optical set is **individually** hand-corrected to produce a knife-edge optical null and razor-straight bands under the Ronchi test. This battery of three independent optical tests assures that Meade Schmidt-Cassegrain optics are, without exception, the finest available in any commercial telescope.

Standard-Equipment Worm-Gear Drive Systems — Included with every Meade Schmidt-Cassegrain is the most precise drive system of any instrument in its price and aperture class. The standard drive system of the Meade 8" Model 2080, for example, is now almost legendary among serious amateurs and has been responsible for some of the finest astrophotographs ever produced with amateur-owned equipment.

New LX (Long-Exposure) Drive System now Available on Meade 8" and 10" Schmidt-Cassegrains

For the most advanced astrophotographic applications, the new Meade LX Drive System is now available optionally at modest additional cost on the 8" Model 2080; the LX Drive System is now included as standard equipment at no additional charge on the Meade 10" Model 2120. The LX Drive includes custom gear components ground with extreme precision, and permits practical long-exposure photographs up to 2 hours' duration. ***The LX Drive System is warranted to equal or exceed the precision of any drive system available on any production Schmidt-Cassegrain telescope.***

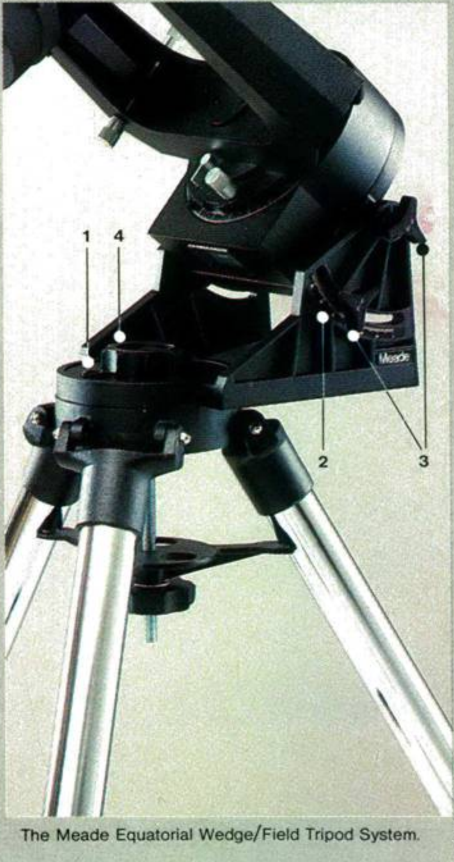


Latitude scale of the Equatorial Wedge.

Advanced-Design Equatorial Wedge and Field Tripod Systems — The owner of a Meade Schmidt-Cassegrain will appreciate the attention to detail shown in the Meade Equatorial Wedge and Field Tripod. Each Wedge includes a latitude scale permitting accurate polar alignment of the telescope in a few **seconds,** not minutes. A universal bubble level, machined into the floor of the Wedge and also included as standard equipment, enables the observer to rapidly align the wedge/tripod system to the horizontal, without guesswork. Azimuth orientation is facilitated by the 360° – rotation capability of the Wedge on the Field Tripod — and by the fact that no wrenches or tools of any kind are required in the operation of 4" and 8" models, and only one hex wrench on 10" models.

The Meade Field Tripod, variable in height from 30" to 44", allows comfortable observing in either seated or standing positions, and is almost universally regarded as the strongest, most rigid astronomical tripod yet developed. With its exceptionally low damping time, the Field Tripod is suitable for the most sensitive astrophotographic, as well as visual, applications.

Systems Engineering — Meade Schmidt-Cassegrain telescopes and their long list of related optional accessories were designed as a system of complementary components. The optional electric declination motor,



The Meade Equatorial Wedge/Field Tripod System.

(1) Bubble level; (2) Latitude scale; (3) No-Tool-Required adjustment knobs; (4) Wedge-to-Tripod lock knob, permitting 360° Wedge adjustments in azimuth.

for example, fits neatly in a cavity at the undersurface of one fork arm. Optional dew shields lock into a track pre-machined into the corrector cell of every 8" and 10" telescope. Other accessory systems, from sliding counterweights to the f/2.64 Schmidt Camera, attach directly to the standard telescopes without customer drilling or adaptation. The motivated observer will find an almost unlimited potential for growth, with an absolute minimum of observing time diverted to equipment maintenance and adjustment.

Great Nebula in Orion (M42). A 50-minute exposure on Ektachrome 400 through the Meade 8" Model 2080.

Lifetime Warranty — In the U.S.A. and Canada, Meade 4", 8", and 10" Schmidt-Cassegrain astronomical telescopes are **warranted for life** against defects in materials or manufacture. (Outside North America, see your Meade international distributor for details on his extended-term warranty.) The Meade General Catalog contains full details on this ultimate protection of your investment in astronomy.

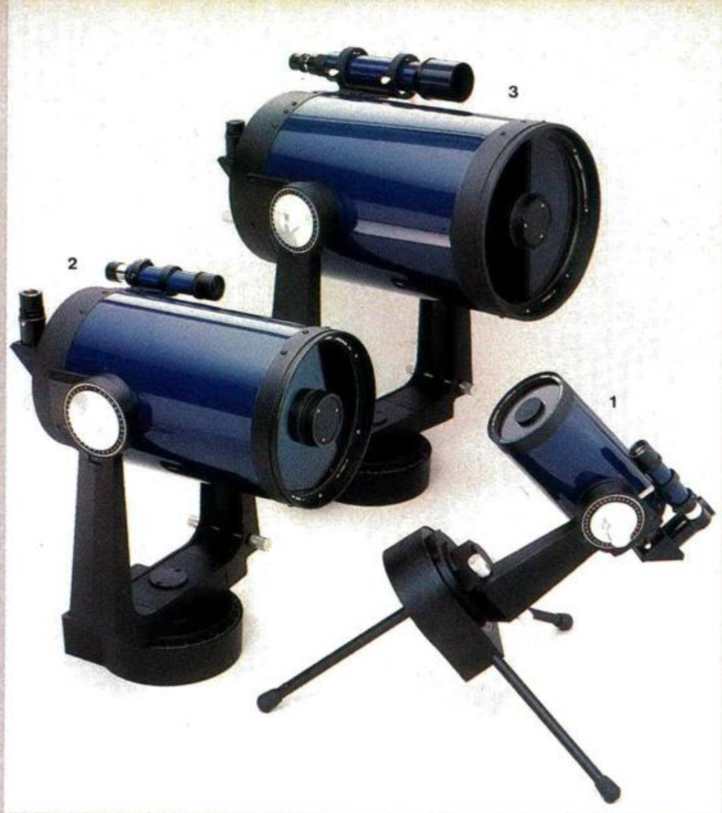
Meade Dealers (hundreds located throughout the U.S.A. and Canada) carry a stock of Meade astronomical telescopes, spotting scopes, telephoto lenses, and accessories, and can offer you further technical information on the wide range of Meade research-quality optical systems — and at surprisingly competitive pricing levels. In the event of a dealer stock shortage on a particular item, we can normally ship to a dealer any Meade Schmidt-Cassegrain complete telescope or accessory within 24 hours.

NEW! MEADE 1000 mm f/11 MAKSUTOV-CASSEGRAIN TELEPHOTO LENSES AND SPOTTING SCOPES

Meade Maksutov telephotos and spotting scopes are manufactured entirely at our Costa Mesa facility. Each model includes a 90mm clear aperture and 1000mm focal length, with all the resolution and performance you'd expect from a Meade optical system. Now available at your Meade dealer's.

OLYMPUS
Meade

Meade Model 90B:
1000mm f/11 Maksutov Telephoto Lens



Meade Schmidt-Cassegrain Telescopes. (1) 4" Model 2044, with standard-equipment table tripod; (2) 8" Model 2080; (3) 10" Model 2120.

Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A. (except Calif.):

1-800-854-7485

From all other areas, including California, dial direct: **(714) 556-2291**

Complete 52-Page General Catalog — $3.00

Send $3.00 for your copy of the all-new Meade full-color **General Catalog #83C**, with many astrophotos through Meade Schmidt-Cassegrains and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

AUTHORIZED INTERNATIONAL DISTRIBUTORS

France
Devaux Chevet S.A.
35, Rue de Rivoli
75004 Paris, France

Medas S.A.
57, Avenue Prés. Doumer
B.P. 181
03206 Vichy, France

Switzerland
E. Aeppli/Spiegeloptiken
Loowiesenstrasse 60
CH-8106 Adlikon
Switzerland

Italy
Ottica F.lli Miotti
Piazza Grandi No. 2
20129 Milan, Italy

Japan
MIC International Corp.
Hoshino Bldg.
7-20, Toranomon, 3-chome
Minato-ku, Tokyo, 105 Japan

Taiwan
B & E Optical Co., Ltd.
P.O. Box 84-621
Taipei, Taiwan

Sweden, Denmark, Norway
AB G Wendelholm
Box 14069 S- 10440
Stockholm, Sweden

West Germany, Austria
Kosmos Service
Postfach 640, Pfizerstrasse 5-7
7000 Stuttgart 1
West Germany

Belgium, Netherlands
O.P.-Slotte
Chaussée D'Alsemberg 59
1060 Brussels, Belgium

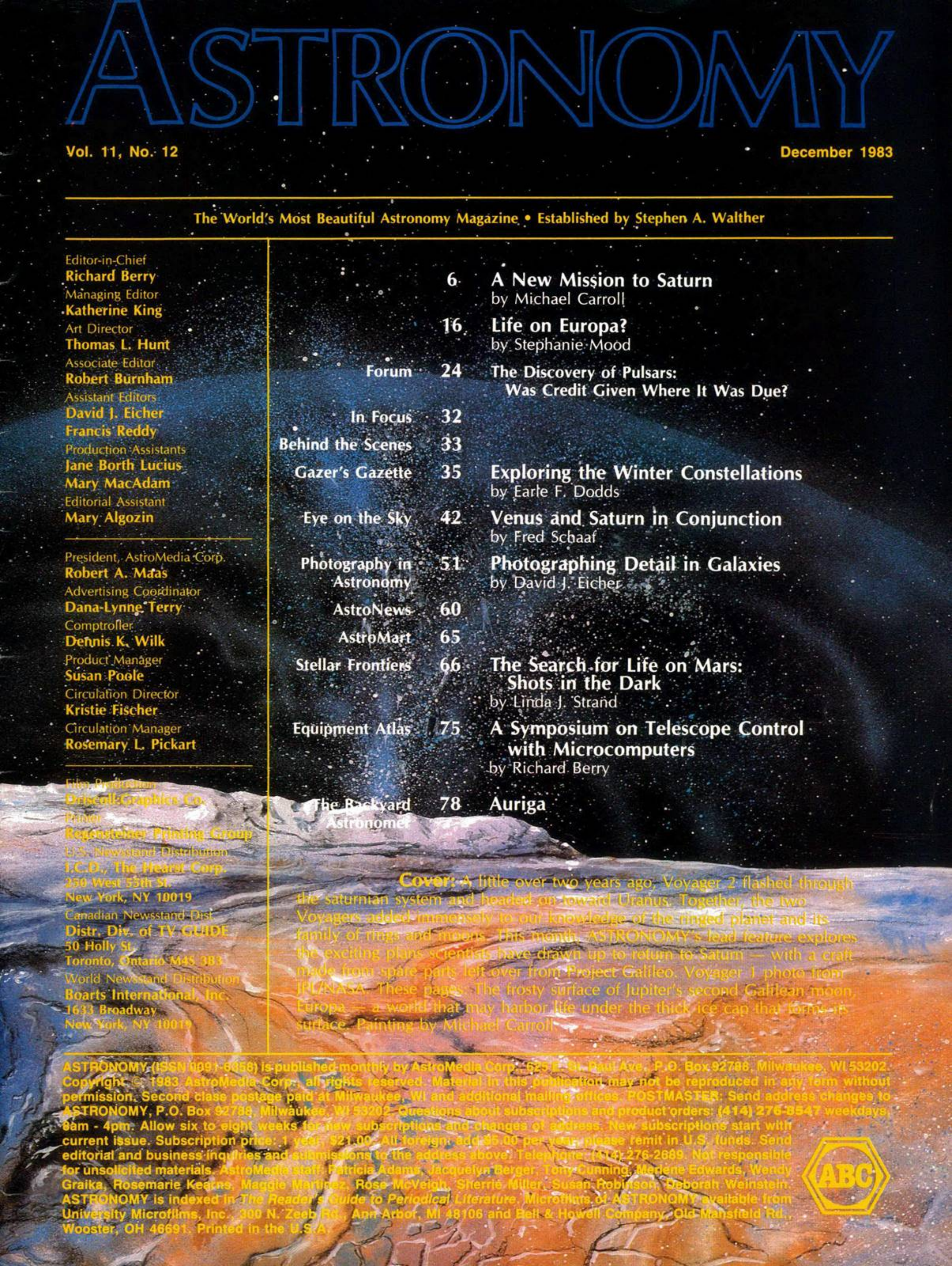
Portugal
Contabilex
Av. 25 de Abril, 13-1°
2750 Cascais, Portugal

Australia
Science World
138 Railway Parade
Leederville, 6007,
Perth, Western Australia

Spain
IMVO/R. Roure Codoñer
C/Col. Legi n. 24
(Bordeta) Lleida, Spain

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, California 92626 ▫ (714) 556-2291

M. Carroll 1983



ASTRONOMY

Vol. 11, No. 12 December 1983

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

Editor-in-Chief
Richard Berry
Managing Editor
Katherine King
Art Director
Thomas L. Hunt
Associate Editor
Robert Burnham
Assistant Editors
David J. Eicher
Francis Reddy
Production Assistants
Jane Borth Lucius
Mary MacAdam
Editorial Assistant
Mary Algozin

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Comptroller
Dennis K. Wilk
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Film Production
Driscoll Graphics Co.
Printer
Regensteiner Printing Group
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
250 West 55th St.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
50 Holly St.
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
1633 Broadway
New York, NY 10019

6 **A New Mission to Saturn**
by Michael Carroll

16 **Life on Europa?**
by Stephanie Mood

Forum 24 **The Discovery of Pulsars: Was Credit Given Where It Was Due?**

In Focus 32

Behind the Scenes 33

Gazer's Gazette 35 **Exploring the Winter Constellations**
by Earle F. Dodds

Eye on the Sky 42 **Venus and Saturn in Conjunction**
by Fred Schaaf

Photography in Astronomy 51 **Photographing Detail in Galaxies**
by David J. Eicher

AstroNews 60

AstroMart 65

Stellar Frontiers 66 **The Search for Life on Mars: Shots in the Dark**
by Linda J. Strand

Equipment Atlas 75 **A Symposium on Telescope Control with Microcomputers**
by Richard Berry

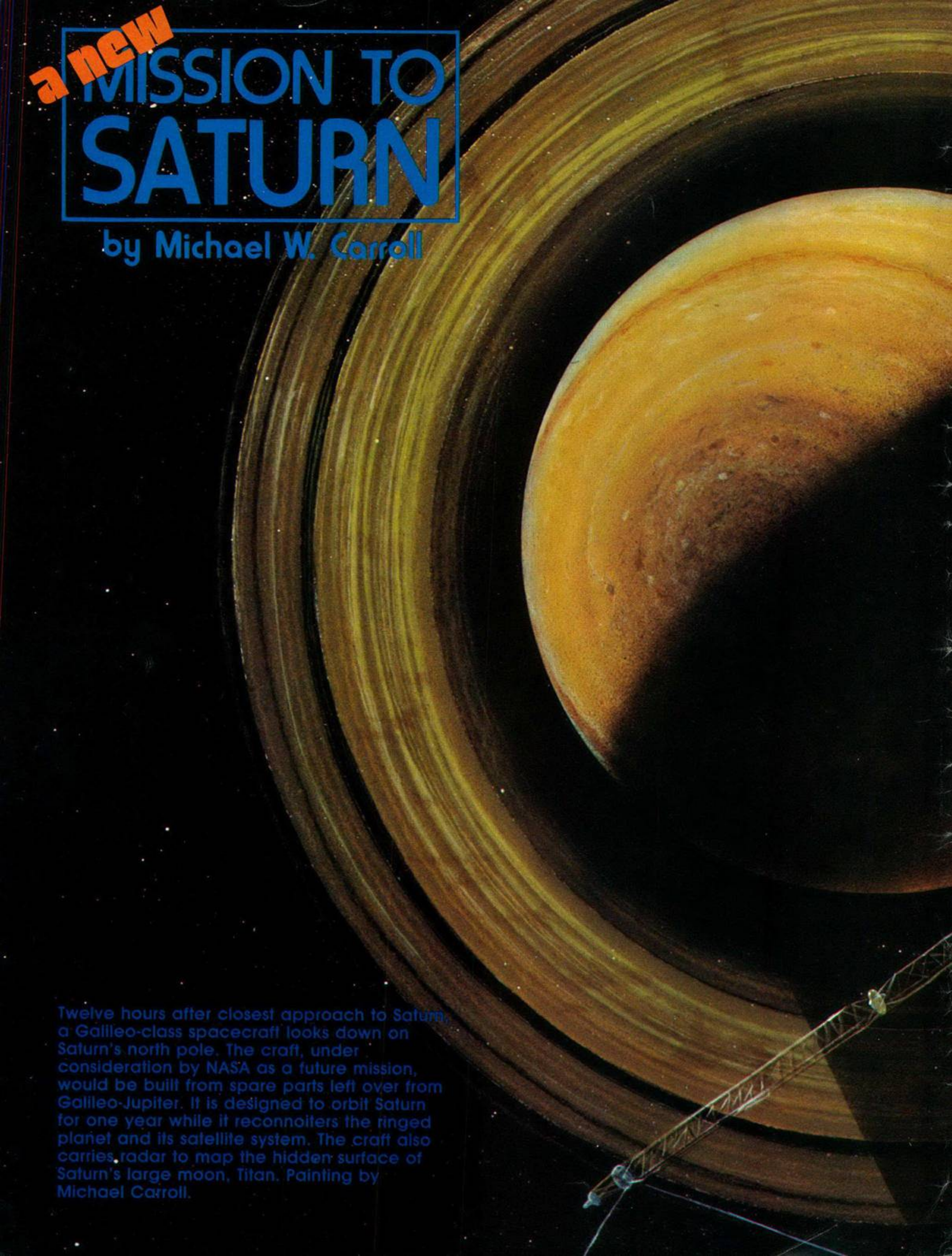
The Backyard Astronomer 78 **Auriga**

Cover: A little over two years ago, Voyager 2 flashed through the saturnian system and headed on toward Uranus. Together, the two Voyagers added immensely to our knowledge of the ringed planet and its family of rings and moons. This month, ASTRONOMY's lead feature explores the exciting plans scientists have drawn up to return to Saturn — with a craft made from spare parts left over from Project Galileo. Voyager 1 photo from JPL/NASA. These pages: The frosty surface of Jupiter's second Galilean moon, Europa — a world that may harbor life under the thick ice cap that forms its surface. Painting by Michael Carroll.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1983 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: (414) 276-8547 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year, please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Patricia Adams, Jacquelyn Berger, Tony Cunning, Merlene Edwards, Wendy Graika, Rosemarie Kearns, Maggie Martinez, Rose McVeigh, Sherrie Miller, Susan Robinson, Deborah Weinstein. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

a new MISSION TO SATURN

by Michael W. Carroll



Twelve hours after closest approach to Saturn, a Galileo-class spacecraft looks down on Saturn's north pole. The craft, under consideration by NASA as a future mission, would be built from spare parts left over from Galileo-Jupiter. It is designed to orbit Saturn for one year while it reconnoiters the ringed planet and its satellite system. The craft also carries radar to map the hidden surface of Saturn's large moon, Titan. Painting by Michael Carroll.

a new MISSION TO SATURN

The Voyager encounters left many mysteries: Why does the saturnian atmosphere behave differently from that of Jupiter? What do differences in composition say about the origins of the two planets? To answer these and many more questions, another mission to Saturn is essential. Voyager 2 photo from JPL/NASA.

Our nation's space program has passed a watershed: with the advent of routine Shuttle flights into orbit comes a new emphasis on cheap, efficient space systems. The days when each new spacecraft represented a significant advance in complexity and sophistication are no more. Throughout the rest of this century, a simple and inexpensive approach to space exploration will dominate every mission that is flown (see "Return to the Planets," ASTRONOMY, September 1983). For example, the $600 million Venus Orbiting Imaging Radar was trimmed to the $250 million Venus Radar Mapper by simplifying its design and using already developed spare parts.

The last "big" space mission in the works that features the sophisticated, multi-disciplinary approach is the Galileo-Jupiter project. This is a flight of magnificent proportions that will send two craft — an orbiter to conduct a 20-month study of Jupiter and its system, and an atmospheric entry probe, which will plunge into the roiling clouds of Jupiter itself. Galileo is slated for launch in 1986 (see "The Galileo Mission to Jupiter," ASTRONOMY, February 1982).

Considering the new emphasis on scaled-down plans, it might appear ludicrous to entertain thoughts of a new and ambitious outer-planet spacecraft. And yet by a quirk of fate, coupled with some good planning, it is possible to mount a Galileo-class expedition to Saturn for about one fifth the cost of Galileo-Jupiter itself. But although the possibility exists, the mission is a long way from the launch pad — in fact, NASA's Solar System Exploration Committee recommended that no action be taken on it, since it might endanger other projects further along in development. If the time isn't ripe at the moment, however, inevitable changes in the budget climate and the politics of science may soon create the opportunity for a Galileo-Saturn mission.

Why Return to Saturn?

The answer is simply that Pioneer 11 and Voyagers 1 and 2 left many mysteries in their wake. While they did increase our knowledge of Jupiter and Saturn several hundredfold, they also taught scientists how to ask questions more intelligent and more probing about these alien worlds and their satellites. After a reconnaissance using flybys, an orbiter is the natural follow-up craft — hence Project Galileo.

Joel Harris, information coordinator for Project Galileo, compared the Voyager and Galileo craft. "Voyager was like flying over San Diego in a 747 at 30,000 feet with a pair of binoculars. You can say that you've seen San Diego. But if you land at the airport, take a taxi to the beach, go to a Charger game, and go shopping in La Jolla — that's more like what Galileo will do at Jupiter. That's what I call seeing a place!"

Since Galileo is the next logical step in the exploration of the jovian environment, exploring Saturn calls for a similar craft. At its closest, Saturn lies almost 1.5 billion kilometers from Earth. It is a gas-giant planet, with a diameter of 120,660 km. Saturn is probably made of the same elements as Jupiter — a concoction of helium and hydrogen similar to the primordial elements that formed the Sun and solar nebula. Its dust-laden magnetosphere, multiplicity of rings, and large family of satellites make Saturn a unique natural laboratory in which to pursue answers to many fundamental questions about our solar system.

Clayne Yeates, Galileo science manager, feels that new Saturn data are essential to our understanding of the solar system. "The abundances of helium and hydrogen and other elements of Jupiter should equal solar abundances, since Jupiter should be little changed since its formation. However, for some reason, these abundances don't match. Sending a probe into Saturn to determine its helium/hydrogen ratio will help confirm our ideas on solar evolution. And Saturn's composition should reflect that of the primordial solar system."

Another important difference between Jupiter and Saturn is the structure of the atmosphere, something that a Galileo-type probe is designed to study. Why are the atmospheric dynamics of these two planets so different? Why does Saturn's system of belts and zones show less mixing than Jupiter's? Why does Saturn's atmosphere have a high-altitude haze layer where Jupiter's is clear, and how does this affect its weather? On Jupiter, easterly and westerly winds seem to alternate along the lines of major belts and zones. But on Saturn, the greater portion of its atmosphere in latitudes near the equator races at supersonic speeds in a single fierce westerly jet stream, four times as fast as winds on Jupiter.

Yeates is also interested in fields and particles that surround Saturn. "The magnetosphere of Saturn is affected by dust in the saturnian system. Its influence is unique in the solar system." Scientists would like to discover the origin of this dust.

The intricate system of rings laced around the planet provides another subject for study. In addition, Saturn's retinue of satellites — 17 at last count — makes up a varied and fascinating group. Six of them are ice balls with surfaces of varying ages and appearances and diameters that range from 400 km to 1,500 km. Ten other satellites are small bodies and may include both fragments of larger moons and captured asteroids.

The one outstanding exception is Titan. It is a planet-sized body in a class of its own and the only satellite in the solar system known to have a substantial atmosphere:

1.6 times as dense as Earth's at its surface. The existence of the atmosphere has been known since 1944, when Gerard Kuiper discovered methane bands in his spectroscopic studies of the satellite. Since then, Earth-based research and reconnaissance by Pioneer and Voyager spacecraft have shown us a strange world shrouded by an opaque, smoggy atmosphere.

Most of our Titan data have come from the two Voyager encounters. Through radio occultation, ultraviolet spectrometer, and photopolarimeter observations, the general structure of its atmosphere and its bulk size were determined. But the cameras proved to be nearly useless. Starting 300 km above Titan's surface, below a thin high-altitude haze, a thick photochemical smog blocks any attempt at conventional photography. Sunlight falling on this cloud layer stimulates chemical processes which create organic compounds that may resemble those which existed on the Earth when life began.

In gross physical properties, Titan is similar to Jupiter's largest satellites, Callisto and Ganymede. Its diameter — 5,150 km — lies between those of the two jovian moons, and its density is about the same, approximately 1.9 grams per cubic centimeter. This implies a composition of 55% rocky material and 45% water ice. The moon's surface is probably almost exclusively water ice due to differentiation in Titan's early history.

Under the dusky orange layers of nitrogen haze may lie spectacular landscapes beyond imagination. The thick, sluggish atmosphere probably does not circulate enough to sculpt and erode the surface features to any great extent, so terrain cratered in its initial bombardment 3.9 billion years ago may still be well preserved. A constant rain of organic material, formed in the atmosphere and precipitated out, may blanket the surface, where the temperature is a stinging -180° C.

Recent calculations suggest that conditions at Titan's surface are at the "triple point" of methane. This means that temperatures and pressures are such that methane can exist as a gas, a liquid, and a solid. (Earth's surface conditions are at the triple point of water.) It is conceivable that methane lakes or oceans lap against glaciers of methane ice, while ice mountains dusted with fresh methane snow rise above pools of organic sludge.

"Titan is one of the most fascinating objects in the solar system," Clayne Yeates says. "It's the one place that people are really interested in sending a probe to."

The Saturn Mission

Titan and Saturn are immensely attractive targets for missions, but is it really feasible to propose a Saturn mission for the near future? One answer lies in the Galileo-Jupiter project, which is currently entering the final phases of construction. The budget for Galileo includes funds for spare parts — back-ups to replace any systems in the orbiter or probe that may develop problems before launch. Using flight-qualified spare parts, a back-up spacecraft is essentially available if the Galileo-Jupiter craft should have a major failure. Barring any catastrophes with the prime Galileo craft, the spare parts can be assembled easily to make a twin of it. The cost would be low — in the neighborhood of $100 million (compared to Galileo-Jupiter's $600 million), since the design, tooling, and construction materials are already paid for. Studies are under way to determine what possible missions exist for such a spacecraft. Several avenues besides the Saturn orbiter and probe have been considered, including a comet mission and a Saturn orbiter with Titan probe. The mission planners' goal is to find a way to get the most scientific return for the lowest cost.

After reviewing all the ideas, the planners came up with an optimum mission profile that calls for a launch in January 1987. The vehicle will be the Centaur liquid-fuel booster, taken into Earth orbit by the Shuttle. The orbiter and entry probe will be targeted for an encounter with Saturn in October 1995. The unusually long flight time is due to the craft's special trajectory: the Shuttle/Centaur will send Galileo-Saturn into a three-year orbit around the Sun. At its greatest distance from the Sun (in August 1988), an engine burn will slow the craft by 300 meters per second. This will cause the spacecraft to fall back in toward the Sun where it will fly past the Earth in April 1990.

Sailing by at a scant 225 km altitude, the craft will use the Earth's gravity to propel and direct it out from the Sun again into a trajectory toward Saturn. Five and one-half years later, as the spacecraft approaches the ringed planet, it will deploy an entry probe. This probe could be directed toward either Saturn or Titan, but Saturn is the first choice because of the probe's design. "In order to do a good job of exploring Titan, our probe would have to be modified significantly," says Bill O'Neill, Galileo's science and mission design manager. The cost of this could be high, and this is not in keeping with the concept of a low-budget, spare-parts mission.

However, if the Galileo probe is poor for Titan, it is ideal for Saturn, since it was originally built for Jupiter. The only necessary modification will be a smaller parachute, since Saturn's smaller mass means lower descent velocities. In addition, the planet's smaller mass results in a less dense atmosphere; this means that the probe's descent mission would probably last about 90 minutes — compared to the hour-long lifetime for the jovian probe. As with the Jupiter mission, the orbiter will provide a link between the infalling probe and Earth.

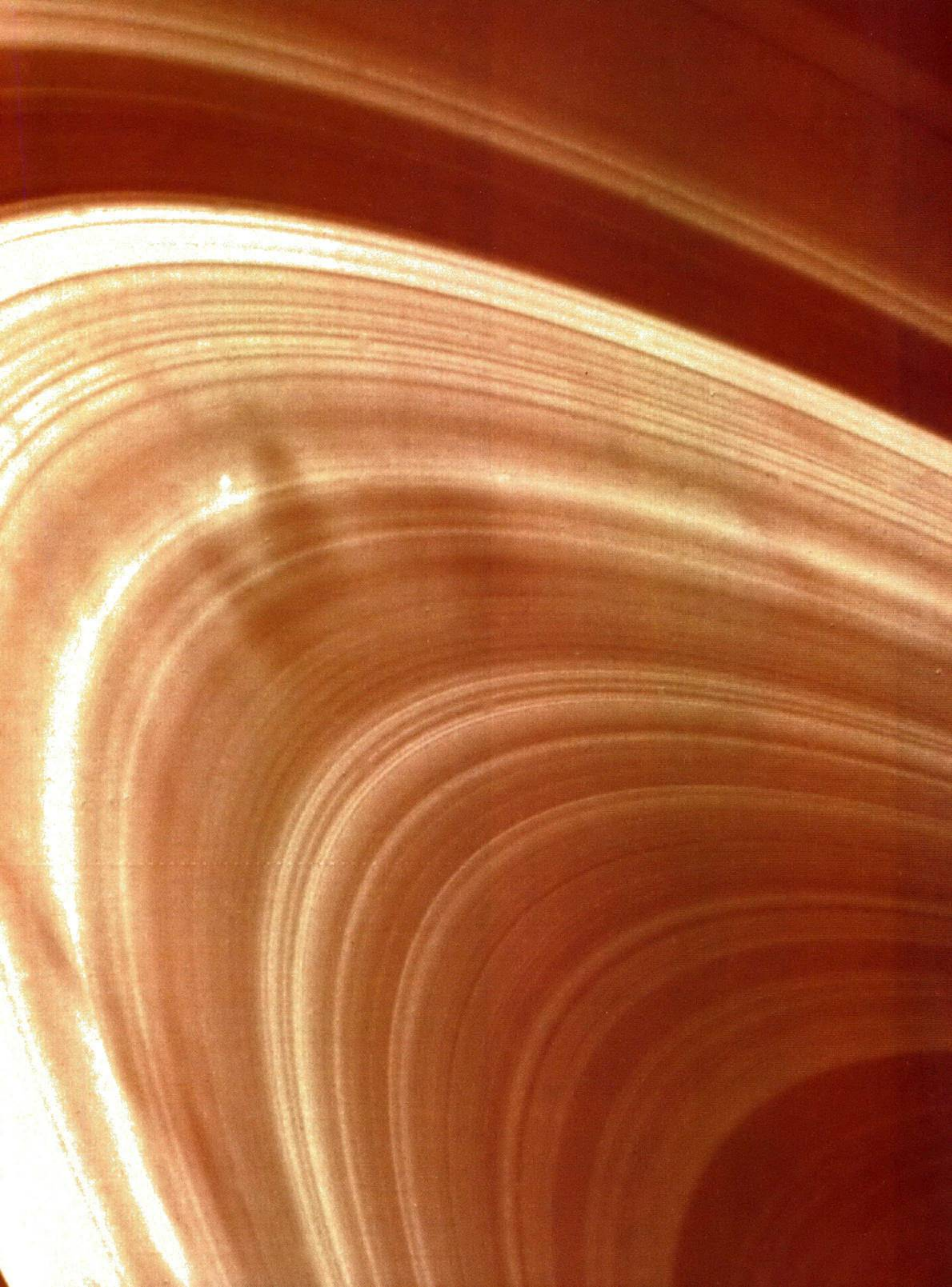
Hours before the probe begins its fiery descent into the atmosphere of Saturn, the orbiter will make a close approach to Titan. Besides providing an encounter opportunity, this swingby allows the orbiter to be slowed by Titan's gravity, thus reducing the fuel necessary for orbital capture.

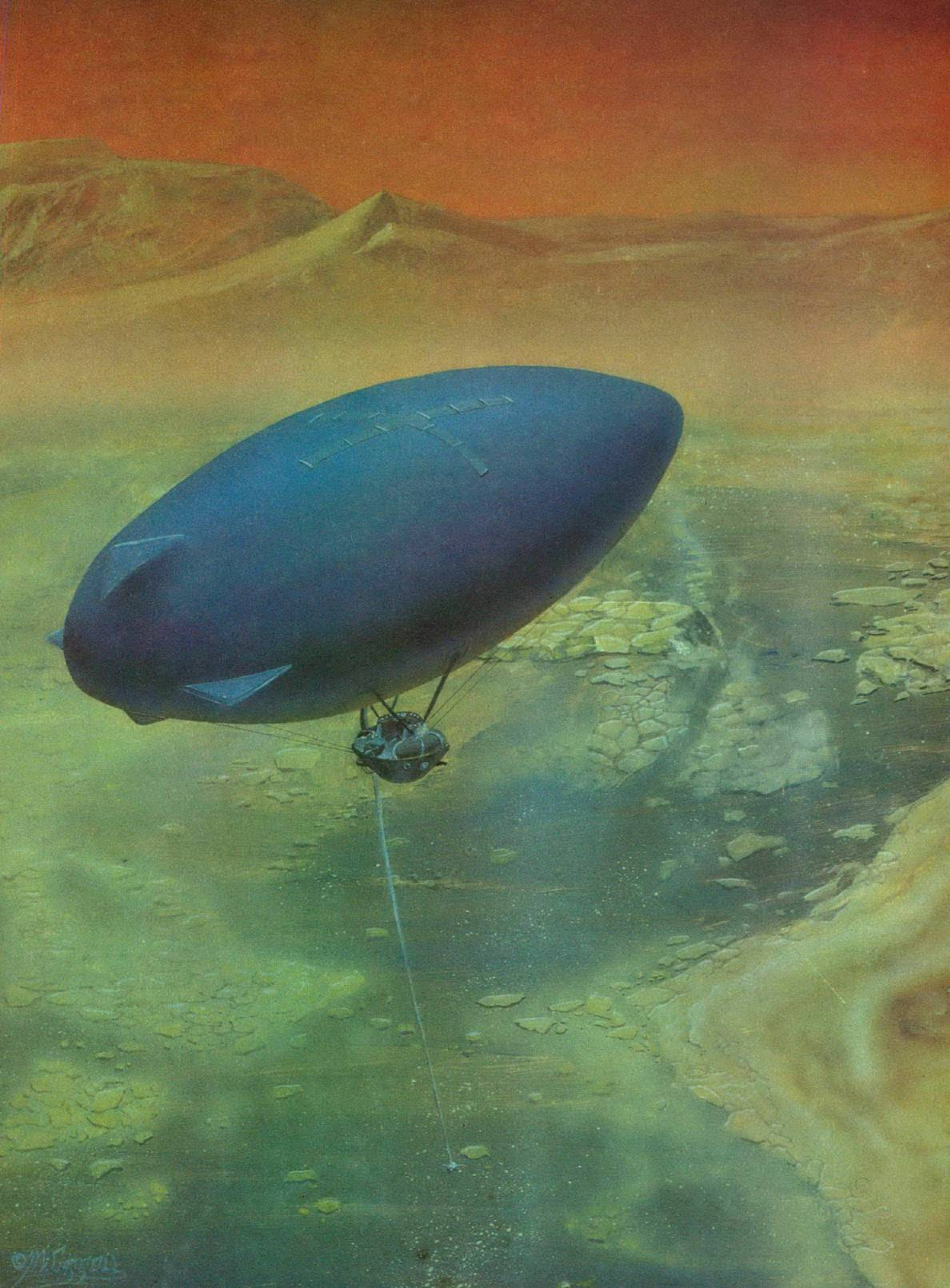
The orbiter will encounter Titan on each of its orbits, since it will reconnoiter the saturnian system from polar orbit. The first flyby brings the orbiter to within 1,700 km of Titan. On the second orbit, the spacecraft will encounter Titan at a range of 1,100 km, Enceladus at 36,000 km, and Mimas at 100,000 km. Each of the next four orbits will bring the spacecraft to within 600 km of Titan and will also include encounters of Enceladus and Tethys.

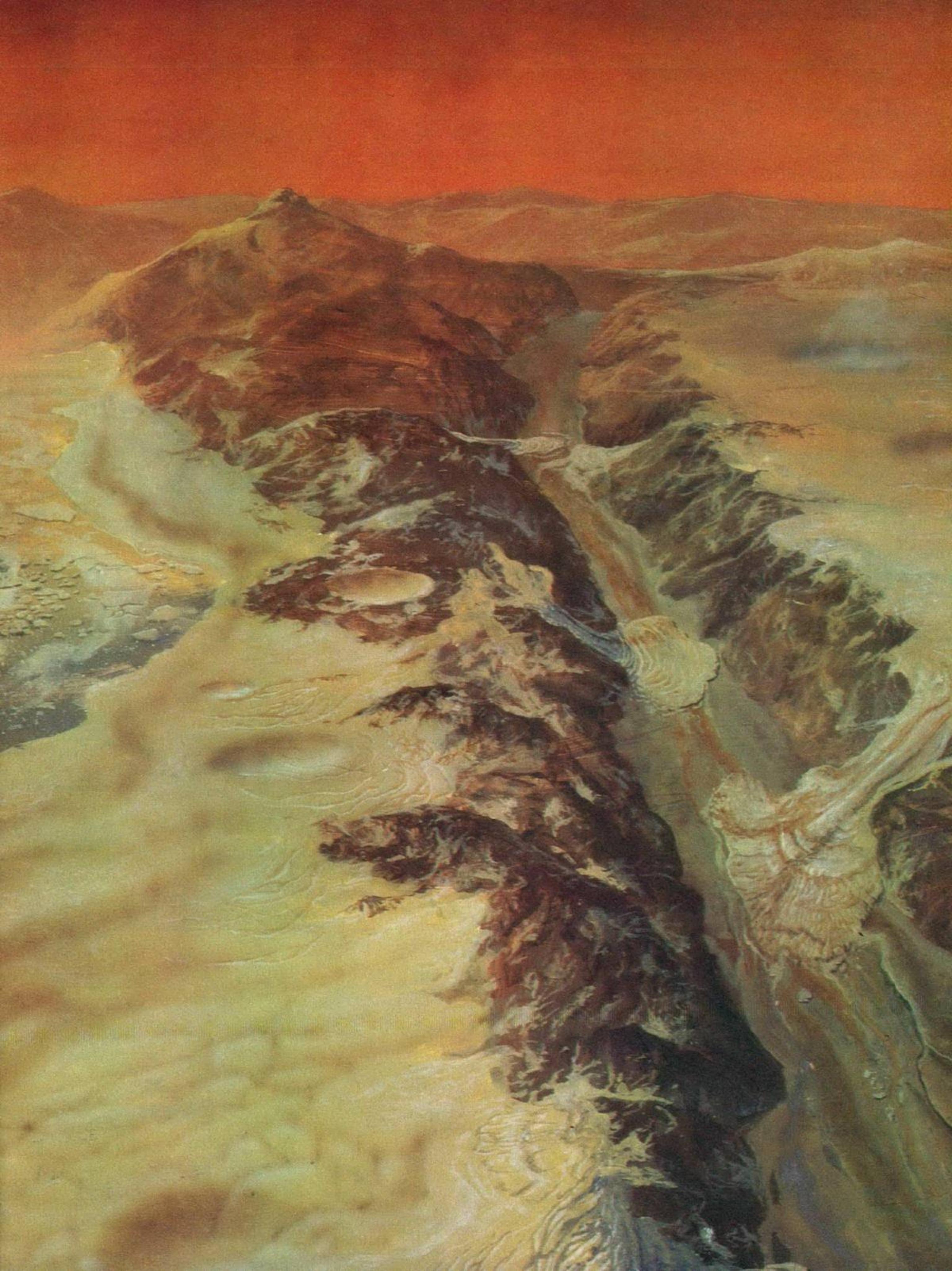
An important feature of Galileo-class spacecraft is that the imaging systems use charge-coupled devices, which will give a resolution of 10 to 20 meters at Saturn. (The cameras aboard Voyagers 1 and 2 had a resolution of 1

Right: Voyager showed us ringlets, "gaplets," spokes, and rhythmical changes — all hinting at processes we've only begun to understand. Voyager 2 photo from JPL/NASA.

Overleaf: Floating above a methane ocean, a blimp-like Titan probe of the 21st century scrutinizes the alien world below. Methane glaciers and ice floes obscure impact craters, while in the distance an oily rain of organic matter falls from the dim titanian sky. Painting by Michael Carroll.







After studying Saturn, its rings, and Titan, the next area of focus for Galileo-Saturn will be the rest of the moons. Across the surfaces of these pockmarked worldlets, impacts have written a history of events that can tell us much about the evolution of the saturnian system. Voyager 1 photo of Dione from JPL/NASA.

to 5 *kilometers.*) The new imager and the other experiments will allow in-depth studies of all the satellites, with compositional mapping of the satellites' surfaces and high-resolution imaging of Iapetus. Tracking the perturbations in the spacecraft's path will yield improved satellite mass measurements. On the planet, long-duration ring observations will provide a detailed history of how the spokes and spiral waves develop. Data will be collected for studies of the dynamics of gravitating disks, and searches for large individual ring particles will be carried out.

The orbiter will also be dedicated to the study of Saturn itself — observing weather patterns, temperatures, and composition of the atmosphere through remote sensing. The descent probe will make *in situ* measurements of Saturn's atmosphere, determining the structure and location of cloud layers, the nature of cloud particles, and monitoring the energy flow outward from the planet and downward from the Sun.

The Saturn orbiter will have one significant addition to the Jupiter configuration: imaging radar. Project scientists can add a radar mapper to the craft with no detriment to the other scientific investigations. The mapper will use the high-gain antenna normally used as the relay to the probe and will give us our first look at the surface of Titan. On each pass of the orbiter, mapping can begin at a range of about 5,000 km. The "footprint," or area imaged by the radar at any given moment, will vary in resolution from 17 to 150 km. In addition, about 10% of the surface can be mapped at a resolution of between 1.7 and 17 km.

Scientists say the radar can also detect atmospheric precipitation at rates as low as 0.5 millimeter per hour, which corresponds to a mild drizzle on Earth. The entire surface of Titan can be mapped within six orbits in just over one year. The forces that shape Titan's surface are unique in our solar system, and it is exciting to anticipate the alien vistas that await us beneath the orange skies of this world.

The Future

Looking toward the more distant future, NASA's Titan plans don't stop with the Galileo-Saturn mission; the agency is also pursuing several preliminary studies of much more advanced missions to the strange world. In 1979, a study by the Martin Marietta Corporation of Denver, Colorado, proposed a Titan lander with a conical base. The lander base was crushable so that the craft could touch down on a rocky surface and remain stable. The cone would also allow a stable landing in a snow bank and could float in a pool of liquid methane. This design also included descent imaging of its landing site, surface imaging, meteorology, and sample acquisition.

A more recent study by Science Applications of Schaumburg, Illinois, has come to the conclusion that the ideal exploration approach is a Titan orbiter with one or more buoyant Titan stations, called "atmospheric rovers." This approach avoids the problems of landing on an unknown surface and affords a great deal of mobility. Several small balloons, each carrying a payload of about 20 kilograms, could float at different altitudes to take advantage of zonal wind currents.

Alternatively, a single large station could be deployed within 5 km of the surface. With a small engine and 50 kilograms of scientific payload, the craft (similar to a blimp) could explore globally. A small payload would be lowered on a tether to sample the surface. Thermal control and power would be provided by radioisotope thermoelectric generators. An omni- or dipole antenna would relay data through the orbiter to the Earth. This antenna would be installed on the payload or on top of the balloon itself, depending on the material chosen for the flotation system.

Science instruments would include nephelometers (to measure atmospheric transparency), spectrometers, radar altimeters, and infrared or visible imagery. Other systems being considered for the Titan station or its orbiter are surface penetrators and sonar buoys for methane ocean areas. A tethered payload would incorporate seismometers and surface samplers. This advanced Titan exploration mission could be launched around the turn of the century; it would have a life expectancy of several weeks to several months.

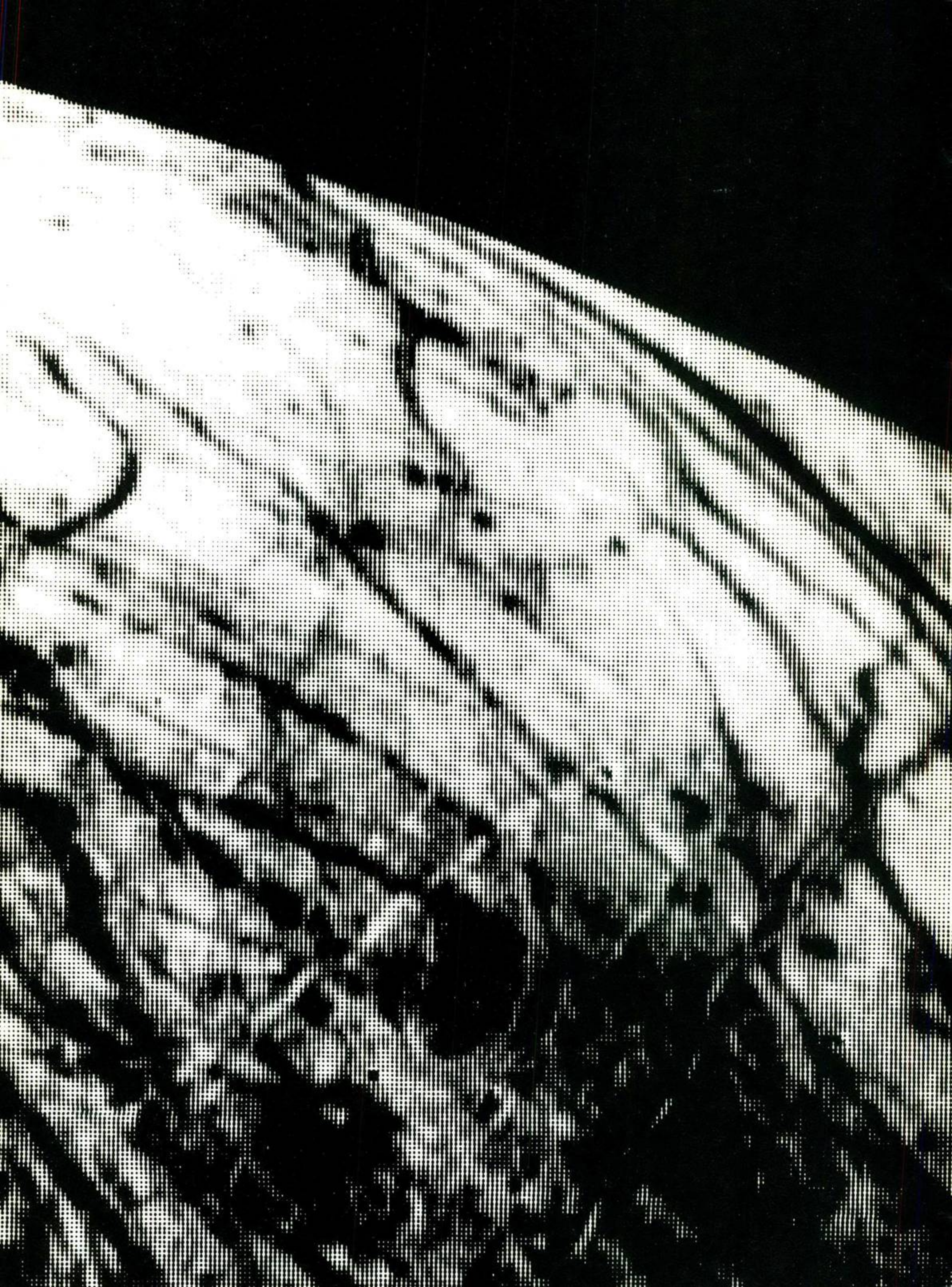
But these exciting possibilities are strictly for the future. "We are assuming that Galileo-type missions are precursors to ours," explains Al Friedlander of Science Applications. "A mission of this kind is a long way down the road."

At present, the Galileo-Saturn mission is not yet a reality. It was proposed to NASA's Solar System Exploration Committee in February of this year and deemed inappropriate for current pursuit. For the time being, it is "on hold," but by next year this plan — or one like it — will be studied again in earnest. The Galileo-Saturn idea has some compelling economic and scientific aspects. Joel Harris summed up the situation this way: "The ironic thing is that we have the hardware, we have the technology, we have the chance to take something that we know will work for a fraction of the cost. When you can have a mission for a quarter or a fifth the cost [of Galileo-Jupiter], it's a shame to let something like this go."

The staff at NASA and the Jet Propulsion Laboratory are not the only ones interested in a spare-parts mission to Saturn. The European Space Agency is in the process of negotiation for a cooperative venture in which NASA would build the orbiter, while the Europeans would build an advanced probe to be dropped into Titan's atmosphere. This proposal is very attractive to NASA for financial as well as scientific reasons. NASA has asked the Europeans to decide before the end of this year, so that plans for the proposal can be included in the fiscal 1985 budget. This is to prevent any budget conflict with a 1986 new-start proposal for the Mariner Mark II comet rendezvous mission.

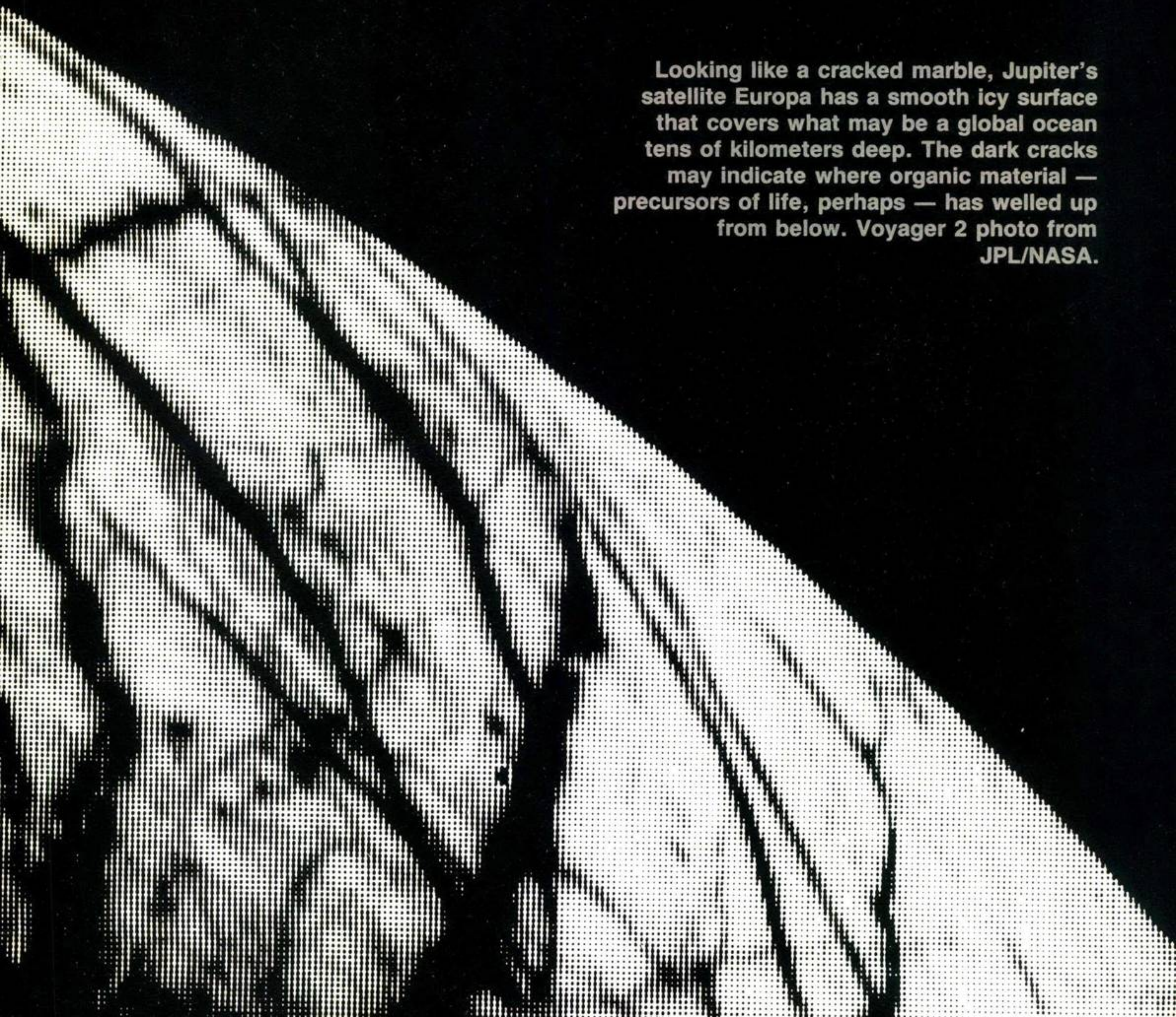
Given the dramatic scaling down of our nation's planetary program, a high yield, low-cost mission would indeed be a boost for morale as well as a boon for science and exploration. Saturn, Titan, and the rest of the magnificent saturnian system await us. In whatever version, Galileo-Saturn comes out as a first-class bargain.

Michael Carroll lives in San Diego, where he is a free-lance space artist and writer. His paintings have appeared in ASTRONOMY many times; his last article, "Space Art in Hawaii," ran in the January 1983 issue. He wishes to thank the staff at the Jet Propulsion Laboratory for their help in researching this article.

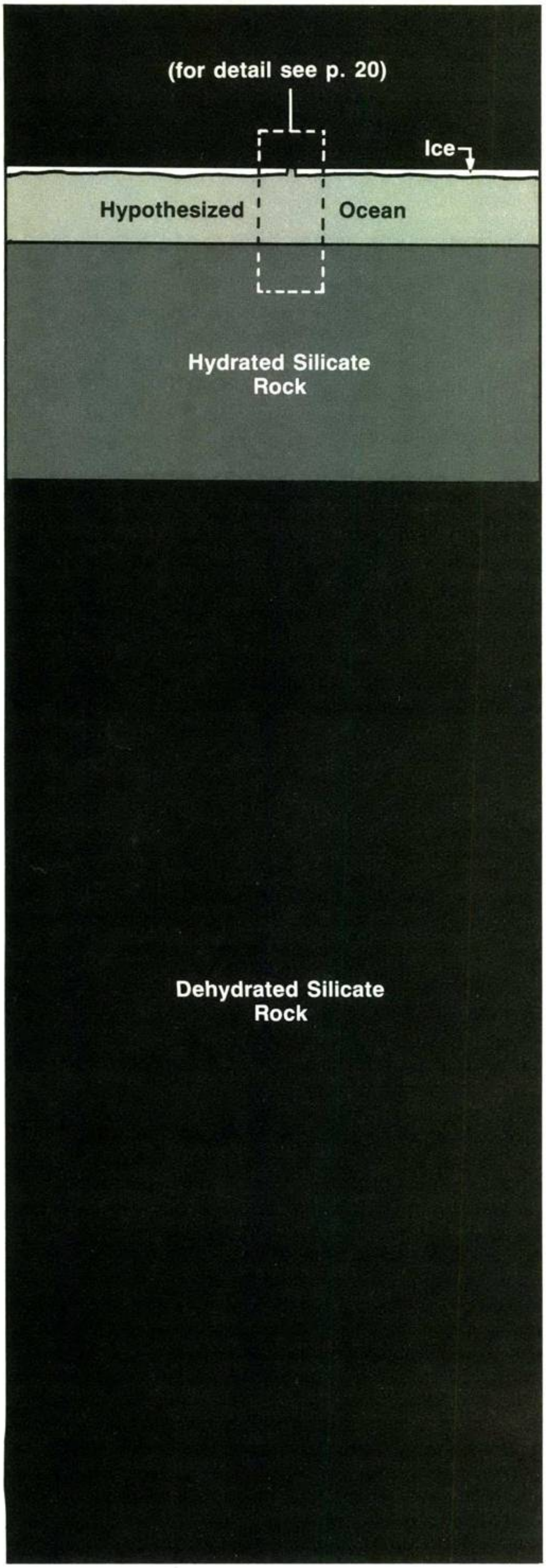


Life on EUROPA?

by Stephanie Mood



Looking like a cracked marble, Jupiter's satellite Europa has a smooth icy surface that covers what may be a global ocean tens of kilometers deep. The dark cracks may indicate where organic material — precursors of life, perhaps — has welled up from below. Voyager 2 photo from JPL/NASA.



The other night, while peering through the telescope at Jupiter and its moons, my mind journeyed to a place I'll never physically visit. Yet this place — like many others in the solar system — has become familiar to me in a vicarious way. I'll never tread the surface of any of these worlds, but thanks to Voyager, it's easy to imagine doing so. If you could go anywhere in the solar system you wanted, where would you pick to go first? If I had a choice, I'd hitch a ride to Europa.

Europa, Jupiter's second Galilean moon, hangs like a cold white ball in space. But despite its apparent blandness, it is one of the most fascinating objects among the jovian worlds. It has a smoother surface than any other object we humans have found in the solar system and is unusually bright, having 10 times the reflectivity of the Earth's Moon.

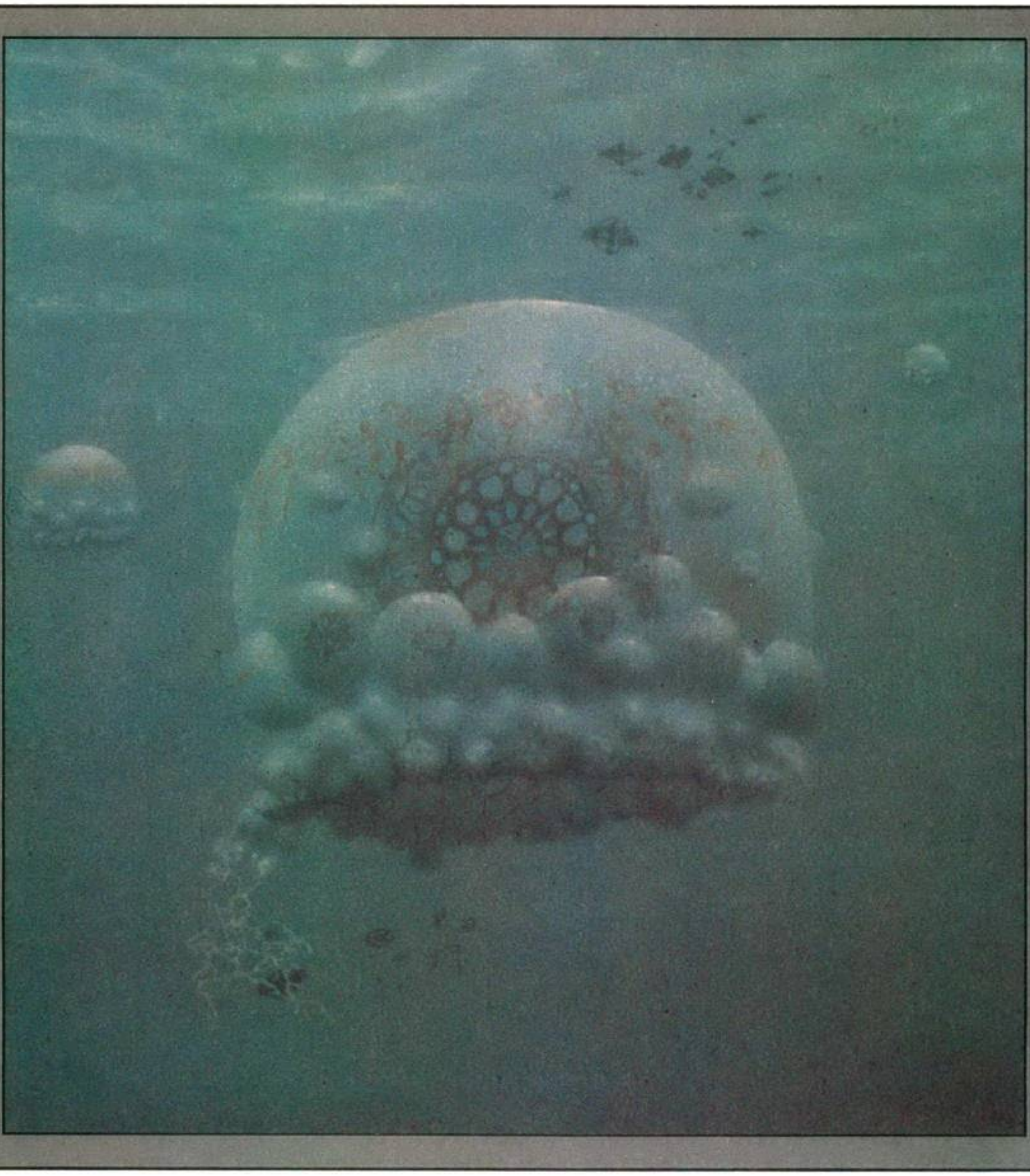
Jupiter and its four major moons have often been seen as a miniature solar system. Io, closest to the giant, is devoid of icy material and is geologically the most active. As we move outward from Jupiter, the moons have progressively more ice in their make-up. Europa, next out from Io, shows a lesser amount of activity, Ganymede is third, and Callisto, the farthest out, has the least activity and the most ice. Some of Io's volcanos, larger by far than any on Earth, are probably erupting this very moment. Quieter Europa is shrouded under a peculiar mantle of ice, Ganymede's surface shows craters and places that have been re-surfaced and re-cratered, and icy Callisto has probably not changed much in the past four and a half billion years.

Each moon has intriguing features, but Europa's enigmatic appearance invites closer scrutiny. You find yourself poring over the Voyager photos in an effort to penetrate the mysteries of its exceptional smoothness and brightness. The frozen surface markings resemble nothing so much as Arctic pack ice — large white floes divided by thin lines of darker ice, which on Earth would be lanes of open water.

Virtually everything we know about Europa comes from what we saw in two quick Voyager fly-bys. We have read the moon's temperature, taken its picture, measured its spectrum, weighed it, pondered its topography, and speculated about its interior. Europa seems to be covered with an icy mantle, and some scientists believe that it has an ocean of liquid water underneath. Several years ago, science writer Richard Hoagland tied a number of findings together and wrote an essay that explored a startling idea — that life may have evolved on Europa. Suppose, he wrote, that Jupiter remained hot enough for long enough to breathe life into its second moon. Jupiter no longer supplies any warmth, but one can indeed imagine life of some sort evolving in Europa's planet-girdling ocean during eras long past, when the moon was basking in the warmth of a newly formed Jupiter.

And perhaps that life is still swimming or floating darkly under the thick ice crust, taking warmth from tidal heating or some other means. It would probably have had to develop some way to use energy apart from

In this schematic cross-section through Europa, a core of dehydrated silicate rock is covered by a layer of hydrated ("wet") rock. Above this is an ocean that could be as deep as 100 kilometers, topped off with a layer of ice from 1 to 10 km thick. (See page 20 for an enlargement of the topmost layers.)



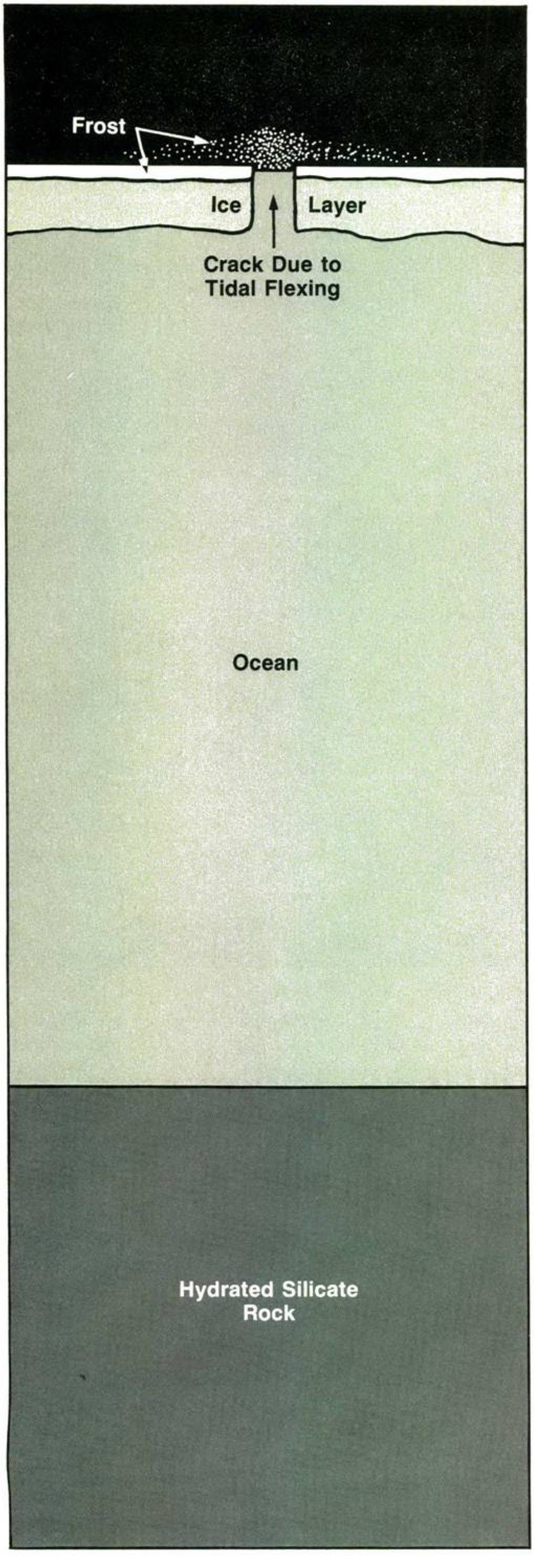
Hypothetical europan life: just under the icy crust, colonies of transparent creatures form large balloon-like beings. Wispy tendrils make nets to catch and digest the small dark organisms. These thrive on the dim light that seeps through the ice. Painting by Michael Carroll.

photosynthesis, a process which depends on light. But on Earth, we've found that the deeper we dive, the higher we climb, the more we see that life, once it begins, persists with a marvelous tenacity.

Look at Europa — it seems almost to shine. Its surface is smooth with networks of dark and light grooves and bands. Voyager 1's pictures showed a somewhat tan mottled marble; after Voyager 2's closer look, we could see this "marble" looked badly cracked — its irregular lines showed dark brown, and some strangely scalloped lines appeared white, almost lacy in appearance. But these scars and streaks are not really depressions; they have no topographical significance at all. As best as we can tell from Voyager's limited reconnaissance, if you were to walk across them, they'd appear only as slightly darker patches of ice some 50 to 200 kilometers wide, stretching several hundred to several thousand kilometers long. Ernest Schonfeld, of the Johnson Space Center, thinks these brown streaks may indicate synthesized organic compounds. Certainly, he says, it's reasonable to assume the presence of methane, ammonia, and water as part of the primordial volatiles of Europa, just as they were for Jupiter. These molecules are among the ingredients necessary for life. Given benevolent conditions and a body of water kept warm — who knows what may be happening on Europa?

Look once again: Europa is as smooth as a cue ball and flatter than the state of Kansas; it shows very little evidence of cratering. In fact, scientists have identified only three relatively small craters on it, each between 18 and 25 kilometers in diameter. Yet we know that all bodies in the solar system have been pounded repeatedly by impacts. The only smooth, clean surfaces are those where some process has erased most or all of the craters, resetting the "impact clock." For example, on our own planet, conservative estimates say that each century several meteorites strike with enough force to gouge out craters more than 10 meters across. One in Arizona is three kilometers in diameter and only 20,000 years old. But Earth is quite active geologically — winds and rain do their work quickly — so there aren't many craters to be seen here. We have identified only a few dozen as being clearly meteoritic, and none are very old in solar system terms.

Somehow the majority of craters on Europa must have been erased, leaving it looking like an ice rink. Perhaps it had an atmosphere at one time — or ice flows could



still be forming. Or maybe there's just some invisible ice-keeper relentlessly filling in holes — the universe loves to tease and joke.

Europa's young surface tantalizes the imagination. You wonder what process obliterated the primordial craters, and whether it's still going on. Io's volcanoes are tidally driven — could Europa be drawing energy from these same powerful forces? Recently, apparent evidence of geyser activity on Europa was announced by astronomer Allan Cook, who found it when he computer enhanced a photo made by Voyager 2 on July 13, 1979. Both an anomalous bright spot and an apparent plume against the blackness of space tantalizingly suggest a watery parallel to the discovery of Io's sulfuric volcanism. With a crack in the icy mantle of Europa, a geyser consisting of water, ammonia, and probably other material could erupt — a direct result of the stresses caused by the endless tug-of-war between massive Jupiter and Europa's neighbor satellites, Io and Ganymede.

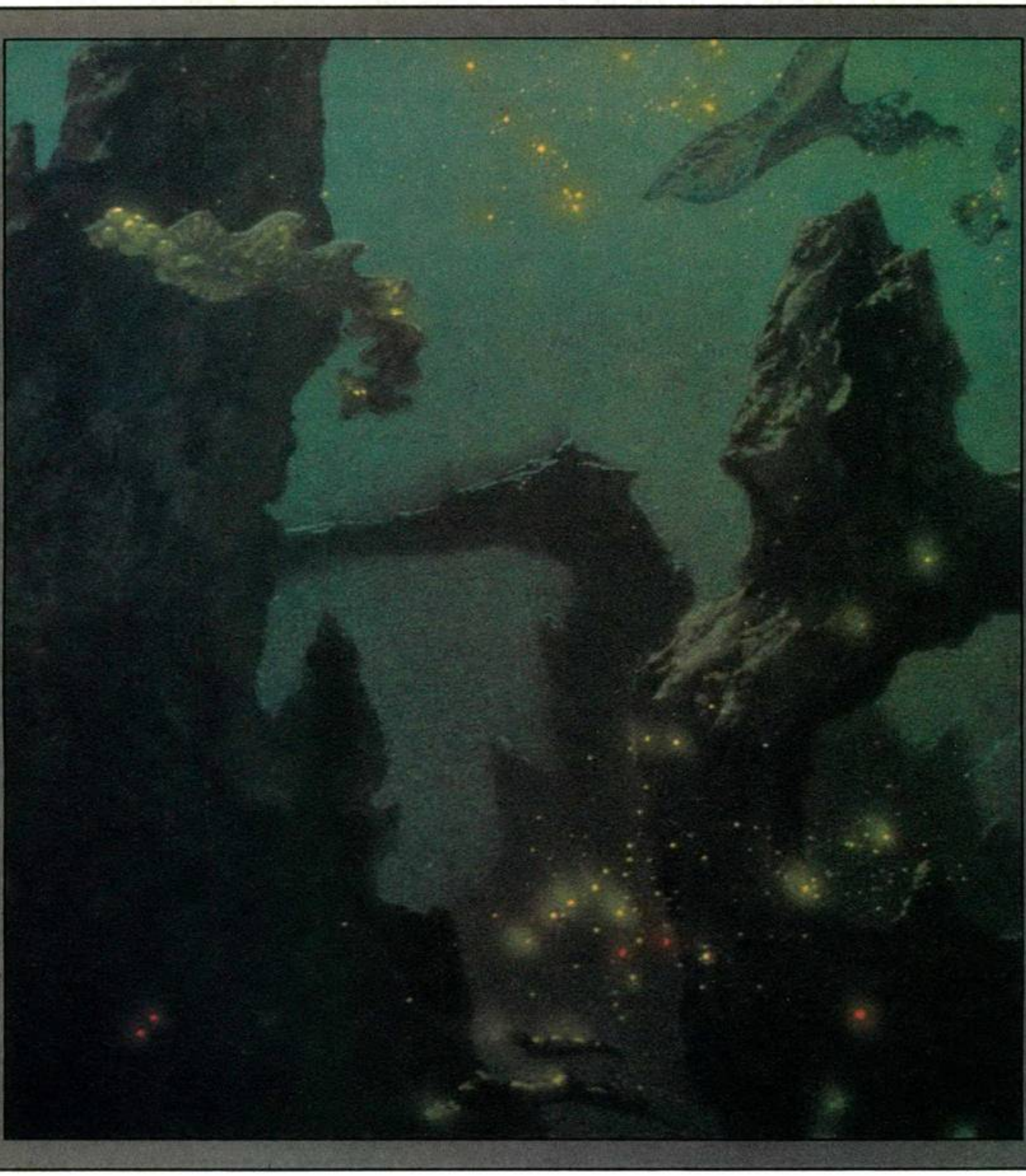
We can find further clues from studying Europa's composition. Europa's density is 3.04 g/cm^3 (the density of water is 1.0). This is less than that of our Moon (3.34), which is typical of the smaller terrestrial-type planets. A density of 3.04 indicates a rocky, or silicate, composition with about 20% water — an impressive amount, since water accounts for only 1% of Earth's composition and we are the solar system's "water planet."

As a result of heat from Jupiter or heat created by the decay of radioactive elements inside Europa, at least some of the body's water outgassed from the silicates to form oceans that covered perhaps most of the surface of the young moon. Some of the water may well have remained as hydrates, locked up chemically inside the rocks. But if Europa outgassed all of its water, this would have created a global ocean 100 kilometers deep. Given the real possibility of oceans, water vapor, hydrogen, nitrogen, ammonia, methane, carbon dioxide, and Jupiter's heat, it would be very strange if life had *not* evolved on Europa.

As the jovian system aged, Jupiter gradually grew smaller and cooler, leaving its four moons with distinctly different and unique stories. If life did form on Europa, and if its oceans remained liquid until the moon became locked into its present orbital resonance, the resulting tidal flexures would tend to keep the oceans liquid. Whatever forms of life Europa may have had would either adapt or die out. Given enough time, Europa's indigenous life, if it's as tough as terrestrial life, quite possibly would have adapted. We see plenty of evidence for adaptation on our own planet, where life has ingeniously and stubbornly filled ecological niches under greatly varied conditions of heat and light, dark and cold.

And Europa is *cold*. Infrared scans across the moon show an average surface temperature of perhaps −220° F. But ice can work quite well as a thermal blanket, and we don't know what the temperature under the surface is. Air temperatures over the Arctic Ocean can plummet to −34° F, while the ocean under a 3-meter mantle of ice remains at a relatively comfortable 28° F. In short, we can't

Here we see the top of the rock layers, the ocean, and the variable-thickness ice layer capped with frost. The ice and frost prevent the water from evaporating and act as a thermal blanket. Occasionally, cracks in the ice will expose water to the vacuum of space, where it will boil off and renew the frost layer. Diagrams after S. Squyres, R. Reynolds, P. Cassen, and S. Peale



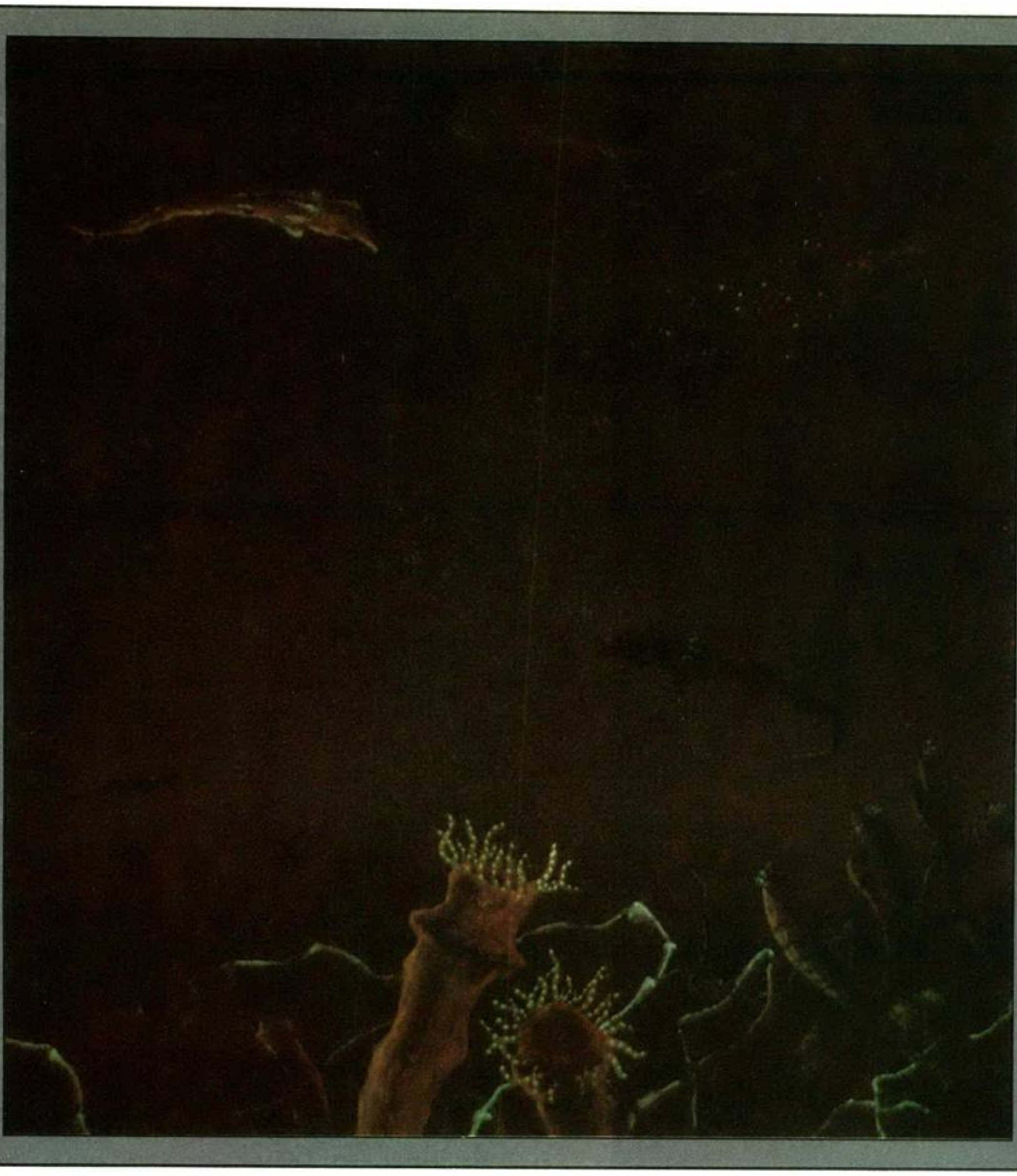
At deeper levels in the europan ocean, we see spongy columns of rock. Strange luminescent organisms are scooped up by the blue swimming creatures, while other rippling beings glide by. Painting by Michael Carroll.

rule out life on the basis of frigid *surface* temperatures. Both plants and animals flourish in Earth's arctic conditions. Plants can create their own colonies and establish microclimates; they can color themselves dark to absorb heat and raise their internal temperatures. Animals come in all forms, with food digestions that match their environment. Lichen, for example, which is part fungus and part alga, grows only ⅜ of an inch in a thousand years, yet it serves to feed thousands of northern forest caribou, the only animal that can digest them. Life is the original radical — it will defeat all odds to exist and persist.

Europa is also dark. Sunlight at Jupiter is 1/27th what it is at Earth, and anything living in a europan ocean would have to survive on very little light. But Earth scientists now know that life exists happily in the dark. We've found small, blind creatures in caves where they've learned to depend on senses other than sight; we've discovered plant-like animals living more than seven miles down in the pitch-dark of the deepest ocean trenches. In *The Sea Around Us*, Rachel Carson describes the luminescence displayed by fish living in dark waters. Some fish, she says, "carry luminous torches that can be turned on or off at will." Terrestrial fishes' eyes may become enlarged — or they may atrophy — in response to the lack of light. Recently, strange new life forms have been found next to the deep-ocean thermal vents they appear to thrive on by chemosynthesis. The list of all possible "life-processes" is by no means complete.

A study released by Steven Squyres, Ray Reynolds, and David Colburn of NASA emphasizes just this. In their study of life in the so-called Dry Valley portion of Antarctica, where vast colonies of blue-green algae exist below ice in temperatures below 32° F, the scientists found life forms photosynthesizing with so little light that humans could not see — roughly what would be available to life under the ice of Europa.

Squyres and Reynolds have also built a novel theory for europan life. Calculations show that cracks in the moon's ice pack must occur constantly as the moon is subjected to tidal forces. For 5 to 10 years after each break occurs, the ice that forms to fill the crack remains relatively transparent. Gradually, though, the ice thickens and becomes opaque, shutting off the soft glow of light from the distant Sun. If any europan life form has evolved to take advantage of low light levels, after each such "crack



At the bottom, the eerie glow of tiny organisms illuminates the dark ocean floor, where sessile life forms feed on detritus from above. Higher up, tube-like creatures swim through the frigid waters. Painting by Michael Carroll.

of dawn" there would be a colossal population boom that would last until the ice aged enough to shut off the light. At any given time there are cracks of widely varying ages all over Europa; thus, despite place-to-place variations, europan life could well exist in a quasi-stable state that swings through cycles of boom-or-bust.

This scenario may never prove true, but we should always remember that life is ingenious. It survives under alien conditions even at our own doorstep. If Europa's organisms existed, they would float or move slowly through a cold dark liquid. They would be the descendants of whatever had evolved in the short time that elapsed between when Jupiter's heat withdrew and other forces took over. What might such life be like now?

Different species would probably live at different levels. Near the surface, we might find weird jellyfish-type creatures whose waste could feed bacteria. These would in turn be eaten by worm-like beings below, organisms that create their own phosphorescence or bioluminescence. There could be long thin grasses or short stubby plants clinging to crevices. There could even be plants hitching a ride on animals. Terrestrial flowers make patterns in ultraviolet light designed to attract insects who perceive in ultraviolet. Pit viper snakes can sense minute changes in infrared — useful for hunting their warm prey. Europa's organisms may well have developed a sort of radiation synthesis.

It's exciting to imagine life so close. Voyager took us to Europa, and Galileo will too. But we could well go again — think how wonderful it would be to land on the moon, cut a hole in the ice, drop down a probe, and find what is really there. If there is anything deep-space missions have taught us, it's that we will not understand most of what we see, and that scientific imaginations tend to fall short of the reality — we are constantly surprised at what exists.

The Sun is a white glaring spot moving through the europan sky; Jupiter fills the view on one side. The ground is like rough stucco everywhere with shallow icy corridors leading nowhere. But what lies beneath?

The other night, I watched Io swing in front of Jupiter while Europa was still hiding behind the planet; I had to wait for her to emerge. Our space program is in shambles today, but Europa will wait for us. Some tomorrow, human beings will stop to visit, and I bet Europa will have more than one awesome secret to amaze and astound us.

SOME REASONS WHY YOU SHOULD MAKE US YOUR FAVORITE CELESTRON TELESCOPE DEALER

- We think our customers are just as honest as we are so we accept personal checks and ship scopes immediately from our large stock without waiting for the checks to clear. Our friends think we are crazy but we feel that a reputable mail order business should be based on trust. You trust us so why should we not trust you? We give you personal service both before and after you order.
- We resist selling you what you ask for if we feel it is not appropriate for your current skills. We specialize in helping beginners choose the correct equipment and accessories.
- You do not have to purchase anything to get the benefit of our 20 years of amateur experience and valued judgement on things astronomical.
- We know the Celestron line almost as well as the manufacturer since we have units in daily personal use.
- We know the strong and weak points of all commercial scopes. Maybe some scope other than a Celestron is best for you — if so, we will tell you.
- We have developed a line of unique Custom Engineered accessories for Celestron telescopes so they will operate with less hassle when fitted with them. NO GIMMICKS — all made to help the beginner.
- **DON'T BE AFRAID** — Our Mail Order shipments to any place in the world are shipped in special scope containers. If by remote chance the scope arrives damaged we ship you a new one and WE handle the claim with the shipper — YOU don't. **WE EXPORT SCOPES WITH ANY VOLTAGE AND FREQUENCY FOR EITHER HEMISPHERE.**

FREE ALL- RISK INSURANCE.

- Do you feel the need of an astronomical friend? Call me. I would be glad to help you. I love astronomy and wish everyone did.

Roger W Tuthill

Celestron 11 on the NEW Heavy-Duty Adjustable Isostatic Equatorial Mount (NOTE storage box in foreground)

- Vibrates 1/2 as much as any adjustable tripod/wedge combination in the marketplace. Structural light-weight aluminum angles, anodized gold for beauty and corrosion resistance. Stable enough to work on the side of a hill. Folds up into a small 4″ x 4″ x 57″ box. Light weight. Finger-tip adjustable in latitude & height without tools. Accessory storage tray available. **MOUNT SUPPLIED FREE WITH EACH C11.**
- **PRECISION POLAR AXIS FINDER** (USA Patent #4,260,253). Get perfect celestial polar alignment quickly and easily every time without leveling your tripod. When the centered 4X crosshairs are set on Polaris the built-in 0.8 degree offset barrel points directly and precisely to the pole. Novel Polaris date and time chart supplied FREE. Now available with FREE Ring-O-Fire Glowing crosshairs for easy viewing.
- **NEW IMPROVED GIANT FINDERS.** 50MM OR 80MM Right Angle or straight thru. Easy mounting to all scopes. Fingertip collimation adjustment. Now equipped with our Ring-O-Fire glowing crosshairs for easy viewing. No wires or batteries.
- **CLAVE, CELESTRON AND TELEVUE PLOSSL EYEPIECES** — ALL SIZES.
- **WE DO NOT SELL EITHER MEADE OR DYNAMAX SCOPES BUT WE MAKE SOME NIFTY ACCESSORIES THAT ENHANCE THEIR USEFULNESS.**
- **LARGE BINOCULARS, NO DU CAPS, LUNA SHADE MOON FILTERS, CAMERA DRIVES, & ILLUMINATED RETICLES.** We sell EDMUND SCOPES TOO. We also sell STAR-TRAP DRIVE CORRECTOR AND ELECTRONIC EYEBALLS AND OUR OWN NEWTONIAN TELESCOPES.

WE FINANCE SCOPES LOOK NOW PAY LATER

CELESTIAL NAVIGATOR

THE MISSING LINK ANOTHER TUTHILL TRIUMPH HIGH ACCURACY/LOW COST DIGITAL CIRCLES

The CELESTIAL NAVIGATOR MARK III consists of separate, independent, self-contained R.A. and Dec. units with built-in batteries good for any country in either hemisphere. SEND FOR USER REPORT.

THE STEREOOCULAR®

A binocular viewing device. Great for spectacular views of the Moon, Sun, Planets, bright nebula and terrestrial objects.

Gives a 3-dimensional effect with brighter views than other units since it takes 1¼″ eyepieces and gives upright images with large prisms and NO barlow.

Two people can view at one time. For use on compound scopes and refractors. Write for user report.

Recognized As Headquarters For Telescope Solar Filters Solar-Skreen® Sun Filter

SOLAR SKREEN Sun filters (USA Patent #3,897,140) fit all scopes and use no glue or magnets. Double aluminum surfaces are shielded from damage. The fine qualities and SAFETY of this filter are described in detail by Dr. B.R. Chou in *Sky and Tel.* pg. 119, August 1981, and *Astronomy* Review, March, 1982 pg. 75.

Send a LARGE (8½__ x 11__) BROWN Self-Addressed Stamped Envelope (2 oz.) if you want complete info including our new FREE catalog which illustrates all our unique aids to your great hobby.

CALL TOLL-FREE 1-800-223-1063

Interested in a Schmidt Cass scope? We urge you to get a Celestron EVEN if you don't get it from us. You will be a lot happier with the optical perfection and proven performance.

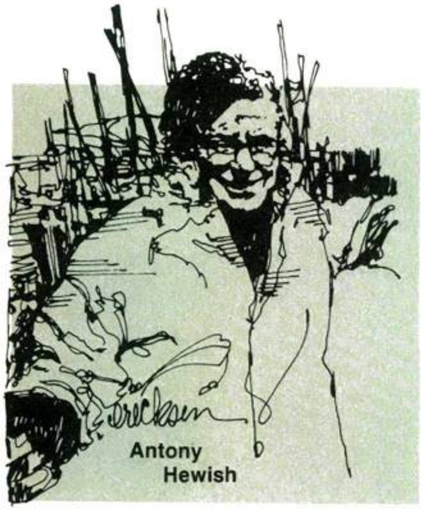
BE READY FOR NEXT YEAR'S ECLIPSE OF THE SUN.

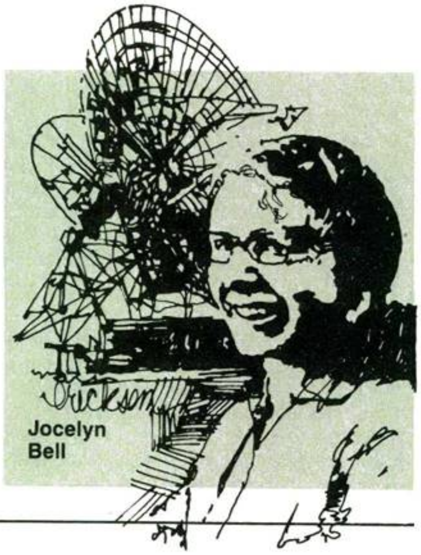
Master Charge, VISA *Trademark

ROGER W. TUTHILL, INC.

In New Jersey phone 232-1786
11 Tanglewood Lane, Box 1086A, Mountainside, N.J. 07092

ASTRONOMY
FORUM





The Discovery of Pulsars: Was Credit Given Where It Was Due?

In 1974 Professor Antony Hewish and Sir Martin Ryle shared the first Nobel Prize in physics presented to astronomers. Among other things, Ryle was honored for the development of the technique of aperture synthesis, in which many small-aperture radio telescopes combine to give the information-gathering capacity of an instrument with a much larger aperture. Hewish was recognized for his role in the discovery of pulsars. Strangely, the astronomical community reacted to Hewish's Nobel Prize by ensuring that Jocelyn Bell would be the most famous graduate student in the history of astronomy. Why? The story begins with a research project for the detection of quasars by radio source scintillation.

In a dark evening sky, the stars rarely appear as steady beacons — they often twinkle, or in the language of astronomers, scintillate. Scintillation results from the random refraction of light waves as they travel through air masses of different densities in our atmosphere. The twinkling of stars also has its counterpart in radio astronomy. Radio source scintillation is caused by the random refraction of radio waves traveling through ionized gas. Celestial radio sources must travel through three distinct sources of scintillation: the ionized interstellar gas of our Galaxy, the ionized gas between the planets of our solar system, and the ionized gas that tops our atmosphere.

Radio scintillation was first observed in 1964 at Cambridge University in England. In subsequent years, all three sources of the phenomenon were identified and investigated. Astronomer Antony Hewish, of the Mullard Radio Astronomy Observatory, played a major role in all three investigations.

In 1967, Hewish began a research project that attempted to detect quasars by using the scintillation effect. Radio sources with large angular dimensions, such as ordinary galaxies, do not scintillate, but very compact radio sources, such as quasars, show rapid, irregular fluctuations in intensity.

Hewish designed and constructed a special radio telescope for his quasar search. The scintillation effect is easier to detect at longer wavelengths, so Hewish designed the radio telescope to operate at the relatively long wavelength of 3.7 meters. The antenna needed a rectangular array of 2,048 dipoles covering 4.5 acres to acquire a sensitivity adequate for the search.

The observing program began in July 1967. The telescope was stationary, but Earth's rotation carried celestial radio sources across the sky and over the local meridian, where the telescope could observe them for three to four minutes each day. Repeated sky surveys, using a receiver sensitive to rapid changes in intensity, were expected to eliminate temporary man-made "electrical interference" sources, and to produce significant contributions to the study of the number and distribution of quasars. Strangely enough, this latter expectation turned out to be the *least* significant and controversial aspect of Hewish's research project.

One of his graduate assistants was Susan Jocelyn Bell. She had become involved in the quasar research program early on, about the time construction of the telescope began. When the observing program started, she was responsible for analyzing the 400 feet of chart recorder paper produced each week and plotting the positions of any scintillation sources. Bell's interpretation of the recordings was to serve as her doctoral thesis.

In late August 1967, Bell drew Hewish's attention to a peculiar scintillating source, a barely noticeable centimeter-long response on the chart paper. The source was in the constellation Vulpecula the Fox. A very weak radio source appeared to be scintillating rapidly when it passed overhead near midnight. Her attention was drawn to the source because scintillation effects usually diminish near midnight as the influence of the interplanetary solar wind decreases.

Hewish disregarded the signals at first as the kind of interference that might be expected from some terrestrial source, since it only

★STAR140

"precision optics you *can* take with you"

The STAR 140™ All-Purpose Telescope

Wherever you go, your STAR 140™ goes with you! Take it to the mountains, seashore, or use it in your own backyard. Big aperture for serious astronomy, yet portable enough that you'll always want to bring it along. Excellent views of the Moon and planets; superb for viewing nebulae and those rich Milky Way starfields. Ideal for deep-sky photography, too!

- big 5.5-inch aperture
- crisp, brilliant images
- wide 1.6° field of view
- handsome, durable epoxy finish
- mounts on any camera tripod

	PRICE	ORDER NUMBER
STAR 140™ Schmidt-Newtonian (telescope only)	**$434.95**	**SP101**
STAR 140™ telescope plus heavy photo tripod	**$534.95**	**SP102**
STAR 140™ telescope plus equatorial mounting	**$734.95**	**SP103**
Barlow Lens (doubles magnification)	**$ 59.95**	**SP104**
26mm precision Plössl Eyepiece	**$ 59.95**	**SP105**
Camera Adapter	**$ 29.95**	**SP106**

(you must supply T-ring for your camera)

INTRODUCTORY PRICE!

SAVE ON OUR TELESCOPE/MOUNTING COMBINATION

$850.00 VALUE

OUR PRICE ONLY

$734.95

Technical Specifications, Optical: Schmidt-Newtonian optical system; 139.7 millimeter aperture; focal length: 508 millimeters; focal ratio: 3.64; laser-calibrated Schmidt corrector plate; 52 millimeter elliptical secondary mirror; full thickness Pyrex primary mirror; standard magnification: 28x; magnification with 26mm Plössl: 19.5x.
Technical Specifications, Mechanical: tube length 19 inches (480mm); tube diameter 6 inches (153mm); weight: 6.4 pounds (2.9 kg); aluminum tube construction; metal dust cover; high-precision ultra-smooth slide focuser with lockscrew; 1.25″ I.D. metal eyepiece drawtube (lockable); sturdy metal ¼″-20 tripod attachment plate; optional camera adapter.
Technical Specifications, Equatorial Mounting: manual right ascension slow motion with 90:1 reduction; manual declination slow motion; 2¾″ x 1⅜″ x-section wooden tripod, legs adjustable from 45 to 59 inches length; positive lockable latitude adjustment; fine adjust in azimuth; built-in bubble level; handy accessory tray; setting circles and locking clutch (both axes); adjustable counterweight; provision for polar axis alignment telescope (not included); felt-lined telescope rings.

★STAR
PRODUCTS

Div. of AstroMedia Corp.
625 E. St. Paul Ave.
P.O. Box 92325
Milwaukee, WI 53202

Telescopes and accessories shipped promptly via U.P.S.

Sorry, but we cannot ship outside the U.S. except APO and FPO.

PHONE ORDERS AND INQUIRIES WELCOME.

(414) 276-7680

Send this coupon or a copy to: **STAR PRODUCTS™, Div. of AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92325, Milwaukee, WI 53202. (414) 276-7680** Phone orders welcome.

☐ **SP101 $434.95** ☐ **SP102 $534.95** ☐ **SP103 $734.95**
☐ **SP104 $ 59.95** ☐ **SP105 $ 59.95** ☐ **SP106 $ 29.95**

Send me the items I have checked (✓) above.

Enclosed is my check/money order for $ ________.

Charge my credit card $ __________.
☐ MasterCard ☐ VISA ☐ American Express

Card Number Exp. Date

Signature Daytime Telephone Number

Name

Address

City State Zip

6S123

appeared for a fraction of the time that a celestial source would be in the telescope's reception beam. The signal also appeared sporadically. By the end of September, it had materialized only six times. The sporadic source also appeared to irregularly alter its position in the sky. In Hewish's opinion, the initial observation seemed to show that the signal did not come from a celestial source. Bell, meanwhile, continued her interest in the source.

After further investigation, Hewish suggested that the apparent shifts in position and frequent lack of signal might be due to chance scintillation effects. The absence of any measurable parallax could only be explained by signals that were not of terrestrial origin. The source — whatever it was — must exist far beyond the solar system. Hewish then suggested that the strange source might be a radio flare star.

The signals disappeared for six weeks starting in October 1967; in late November, Jocelyn Bell reported their return. On November 28, a newly available high-speed recorder was used for observations of the source. The flare star hypothesis quickly died and a new class of celestial object was born. The source was emitting 0.3-second-long radio pulses every 1.337 seconds. The short duration of the pulses meant that the pulsating radio source was small enough to have *planetary* dimensions.

According to Hewish, "the pulses that could be distinguished on the recording, marked the discovery of pulsars." This was, however, his thinking at a later date. At the time of the recording, he was convinced that the short period between pulses definitely identified the origin of the source as *man-made*. Nothing known in space could spin, vibrate, or orbit that fast.

If the pulsar was a natural phenomenon, then there must be more. Bell re-examined approximately three miles of chart paper from the quasar survey for other such rapidly pulsating sources. She found three more.

The first announcement of the discovery of the pulsar phenomenon and an analysis of the radio signal was published in the journal *Nature* in February 1968. In this paper, it was suggested that the pulsar signals were generated by stable oscillations of a white dwarf star or the then totally theoretical neutron star. In the foreword to a *collection* of pulsar papers published in late 1968, Hewish seemed to favor the white dwarf hypothesis. The final identification of the pulsar with a rapidly rotating neutron star rather than a pulsating white dwarf was credited to the combined work of astrophysicists Franco Pacini and Thomas Gold.

Following its publication, Hewish's announcement received some criticism from the astronomical community because of the length of time between the four pulsar discoveries and the *Nature* article. Hewish defended his actions as necessary because of an earlier hypothesis that the signals were possibly due to an extraterrestrial intelligence. Hewish believed that the publicity arising from a premature announcement of the discovery would have impaired important investigations being carried out to test the LGM ("Little Green Men") suggestion. He also never revealed his reasons for withholding the coordinates of the other three pulsars until the April 3 issue of *Nature* — another point of contention for the astronomical community.

Other observatories with steerable telescopes were able to overcome the Cambridge advantage almost immediately after the announcement: "Apres moi, le deluge" could have described Hewish's announcement. Jodrell Bank made a significant contribution to the literature of the Cambridge pulsar in a letter to *Nature* within two weeks of the announcement. A fifth pulsar was discovered in June 1968 by Harvard University radio astronomers G.R. Huguenin and J.H. Taylor, using the 300-foot radio telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia. Astronomers produced a flood of pulsar papers in a very short time. In less than a year, *Nature* reprinted the most significant pulsar articles in book form.

> ***"Perhaps the astronomical community . . . felt Jocelyn Bell was treated unjustly when she was excluded from the 1974 Nobel Prize."***

The discovery of pulsars occurred at Cambridge because Hewish's quasar research program involved the detection of short-period phenomena, for which he needed repeated surveys at meter wavelengths. Other radio observatories had more advanced equipment, but they were operating at the shorter centimeter wavelengths where pulsar signals are weaker. Their equipment also had response times about ten times longer than that used at Cambridge — too long to detect the rapid pulsar signals. The Cambridge discovery was an example of serendipity, an unexpected harvest from seeds sown for another reason.

Hewish's graduate student, Jocelyn Bell, has never been denied credit for a part in the discovery of pulsars. But how much credit *should* she have received? Interestingly enough, her perceived role in the discovery seemed to change in subtle ways after 1974.

In an introduction to the 1968 *Nature* reprint of significant articles on pulsars, F.G. Smith of the Nuffield Radio Astronomy Laboratories at Jodrell Bank wrote, "The discovery of the pulsating radio stars by Miss Jocelyn Bell, working with Dr. Hewish at Cambridge, rivals the early classic discoveries of extraterrestrial radio sources in its importance and its excitement." Smith acknowledged that the discovery belonged to Bell, but at the same time affirmed a commanding position in the discovery to Hewish.

In a preface to his 1977 book, *Pulsars*, Smith wrote, "The discovery of the pulsars by Professor Hewish and Miss Jocelyn Bell in 1967 ranks with the discovery of quasars and the universal microwave background radiation as one of the major advances in modern astronomy." Was the change of status from "working with" to one of equal credit intended? Or was it simply a matter of different word choice in a sentence meant to convey Smith's opinion as to the importance of the discovery? If Smith were the only astronomer to promote Bell's role in this way, it would be of little significance. But he was not.

Astronomy textbooks are probably the most influential interpreters of astronomy and its history. George Abell's *Exploration of the Universe* is one of the classic textbooks in terms of the length of time it has been in print, its number of editions, and its total number of readers. The revisions of the second and third editions of *Exploration of the Universe* fall between the years 1968 and 1974. Each edition contains a section subtitled "Pulsars," but neither Bell, Hewish, nor Cambridge are mentioned. This is not true of the fourth edition, published in 1982.

In the fourth edition, Jocelyn Bell was honored in the "Hall of Fame" of astronomers, a revision peculiar to this latest edition. Her photograph, with the explanation that she "discovered the first pulsar in 1967, while she was a graduate research student at Cambridge University Observatory," was used to begin a chapter on the evolution and death of old stars. She is the only graduate research student to be included with such notables as Copernicus, Newton, and Einstein.

The fourth edition also contains an interesting interpretation of the pulsar discovery. Astonishingly, Abell notes, "In the course of Miss Bell's

Look to Cambridge for Beautiful Astronomy Books

THE NEW ASTRONOMY Nigel Henbest and Michael Marten

Astronomy enthusiasts will enjoy this spectacular full-color survey of well-known astronomical objects as seen not just through optical telescopes but as they appear to astronomers observing them at radio, infrared, ultraviolet, and gamma ray wave lengths. Lavishly illustrated with 170 color plates, this book offers the amateur and professional a unique comparative view of the heavens and a state-of-the-art description of astronomy today. $24.95

SUNSETS, TWILIGHTS AND EVENING SKIES Aden Meinel and Marjorie Meinel

This entertaining survey of visual phenomena seen in the evening and twilight skies opens new vistas to the amateur astronomer. Illustrated wth 112 full-color plates, it describes and explains such phenomena as the earth's shadow, zodiacal light, aurora, and twilights effected by volcanic eruption. It also includes a primer on the physical basis of such events, as well as chapters on twilights and sunsets in outer space and on the effects of comets, meteors, and other such bodies. $29.95

THE ULTIMATE FATE OF THE UNIVERSE J.N. Islam

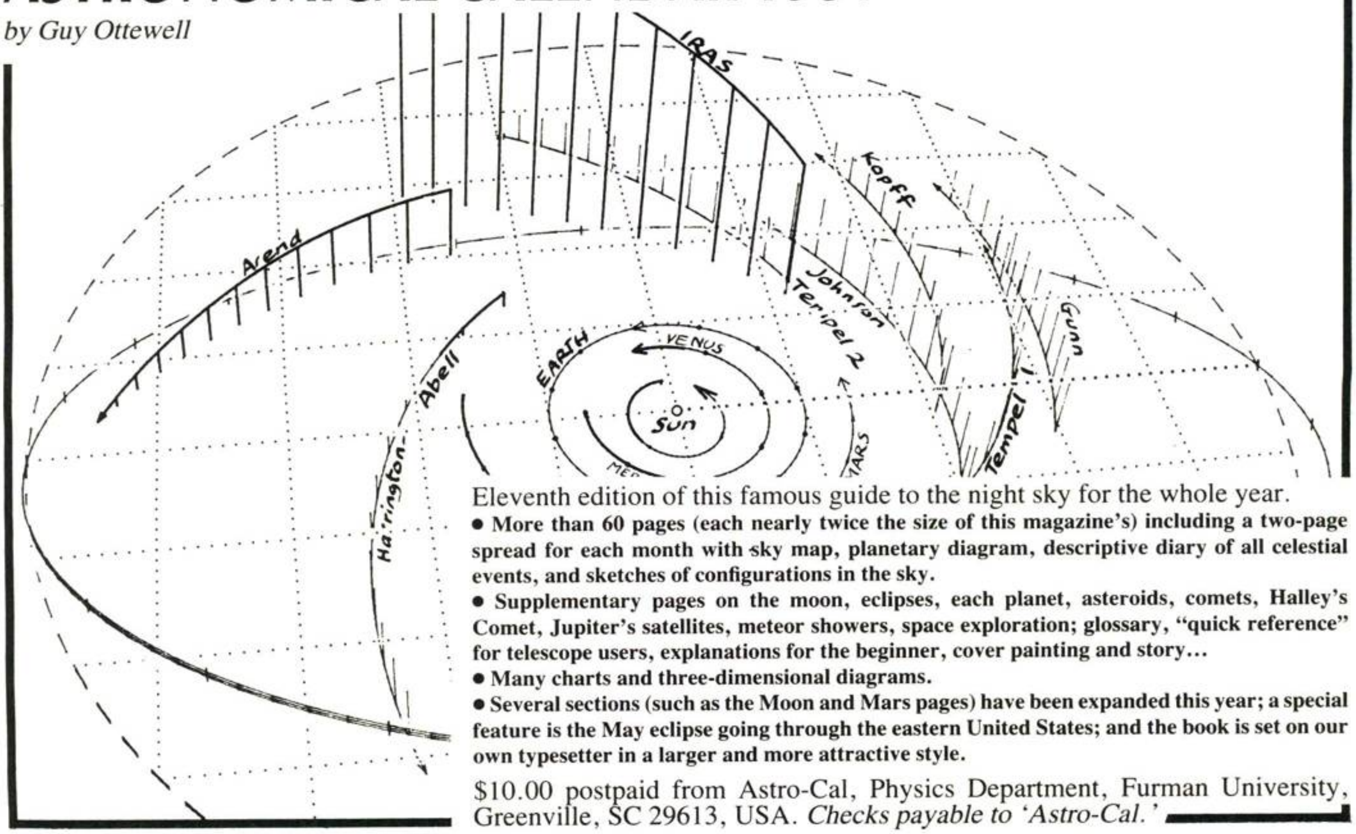
Take an exhilarating intellectual adventure in the latest thinking about the end of our universe. J.N. Islam confronts the controversy about whether our universe is open or closed; explains the three ways a star can die; and describes black holes, quasars, and other phenomena. A simple glossary of terms used and the absence of complicated mathematical formulae make this book accessible to all interested in astronomy. $13.95

Order from your bookstore or call our Customer Service:
1-800-431-1580 (outside NY State and Canada).
MasterCard and Visa accepted.

Cambridge University Press
32 East 57th Street, New York, New York 10022

ASTRONOMICAL CALENDAR 1984

by Guy Ottewell



Eleventh edition of this famous guide to the night sky for the whole year.

- **More than 60 pages (each nearly twice the size of this magazine's) including a two-page spread for each month with sky map, planetary diagram, descriptive diary of all celestial events, and sketches of configurations in the sky.**
- **Supplementary pages on the moon, eclipses, each planet, asteroids, comets, Halley's Comet, Jupiter's satellites, meteor showers, space exploration; glossary, "quick reference" for telescope users, explanations for the beginner, cover painting and story...**
- **Many charts and three-dimensional diagrams.**
- **Several sections (such as the Moon and Mars pages) have been expanded this year; a special feature is the May eclipse going through the eastern United States; and the book is set on our own typesetter in a larger and more attractive style.**

$10.00 postpaid from Astro-Cal, Physics Department, Furman University, Greenville, SC 29613, USA. *Checks payable to 'Astro-Cal.'*

investigation she made a remarkable discovery — one that won her advisor, Antony Hewish, the Nobel Prize in physics, because his analysis of the object (and other similar ones) revealed the first evidence for neutron stars." These statements leave little doubt in the reader's mind as to who the author believes discovered the pulsar. Just how a discovery by one astronomer would win a Nobel Prize for another has probably puzzled many readers who are used to honors being bestowed upon discoverers.

Few textbooks give Hewish as the solitary discoverer of the pulsar, nor does Hewish's name often appear without the name of Bell. They are inextricably linked.

Popular interpretive astronomy books show a similar bias toward Jocelyn Bell. Harry L. Shipman, in the 1976 edition of *Black Holes, Quasars and the Universe*, was more extreme than most textbook authors. He completely ignored Bell's graduate student status and named instead "Bell and Hewish" as equals while discussing the original quasar survey project. He mentions only Bell in connection with pulsars and doesn't mention Hewish's 1974 Nobel Prize at all.

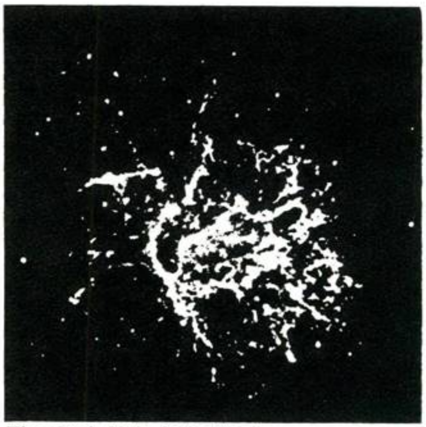
Perhaps the most extreme treatment of the pulsar discovery can be found in Robert Jastrow's 1969 edition of *Red Giants and White Dwarfs*. The discovery of pulsars is attributed to "Jocelyn Bell, an astronomy student at Cambridge University," without any reference to Hewish.

Astronomical magazines have not been immune from promoting Bell as astronomy's most famous graduate student. The December 1982 issue of *Sky and Telescope* includes a "golden anniversary" review of achievements in radio astronomy, which states that Hewish's "student Jocelyn Bell noticed a signal with large and unusual fluctuations." The signal was identified in the article as the pulsar known as CP 1919. The article *then* states that "Hewish won the 1974 Nobel Prize in physics for this discovery" — implying that Hewish won the Nobel Prize for Bell's discovery.

One way to explain this strange situation is in terms of collective conscience. Perhaps the astronomical community, driven by some internal morality, felt Jocelyn Bell was treated unjustly when she was excluded from the 1974 Nobel Prize.

Should the accidental discoverer of a phenomenon be accorded the same recognition as the investigator who establishes the connection between the observation and the underlying cause? The 1974 Nobel Prize committee said "No" in the case of the pulsar. But the Nobel committee of 1978 gave a completely different answer. In 1978 the Nobel Prize for physics was awarded to Bell Telephone Laboratory radio astronomers Arno Penzias and Robert Wilson. While involved in satellite communications research, Penzias and Wilson had discovered an unexplainable microwave signal coming from all parts of the sky. Penzias and Wilson had no idea what the source of the unwanted radiation was. It was finally identified by R.H. Dicke at Princeton University as the background radiation left over from the Big Bang that created the universe. Astronomers at Princeton were in the process of building a microwave receiver to detect what Penzias and Wilson were trying to get rid of!

The Bell Lab astronomers received the 1978 Nobel Prize in physics for their accidental discovery of the cosmic background radiation in 1965. Dicke and his colleagues at Princeton, the investigators who established the connection between the observation and the source, got nothing.



The Crab Nebula in Taurus

It's possible that the treatment given Jocelyn Bell in the pulsar discovery is a reaction to Hewish's treatment of Bell's role, and the initial antagonism that arose when he withheld the coordinates of three pulsars. Hewish has been willing to commend Bell, but only so far. In his Nobel Prize lecture, for instance, he commended her for "care, diligence, and persistence," but nowhere did he allow her the same credit for the discovery as that given by the astronomical community. After outlining the physics of neutron stars in this lecture, and his "good fortune in stumbling upon them," Hewish concluded by stating that Bell's attributes "led to our discovery." This appears to be the only time in Hewish's contributions to the pulsar literature that he has given her that much explicit credit for the discovery.

The ultimate importance of Bell's "care, diligence, and persistence" was revealed in an earlier part of Hewish's lecture. He mentioned that in 1965 he and another graduate student, Sam Okoye, were studying the Crab Nebula. They noticed an unusual scintillating radio component where the remains of the Crab supernova might be found. Hewish suggested that the radio activity was the result of a flare star, but made no follow-up observations — Bell's type of "care, diligence, and persistence" were absent. This "flare star" was later found to be the pulsar within the Crab Nebula.

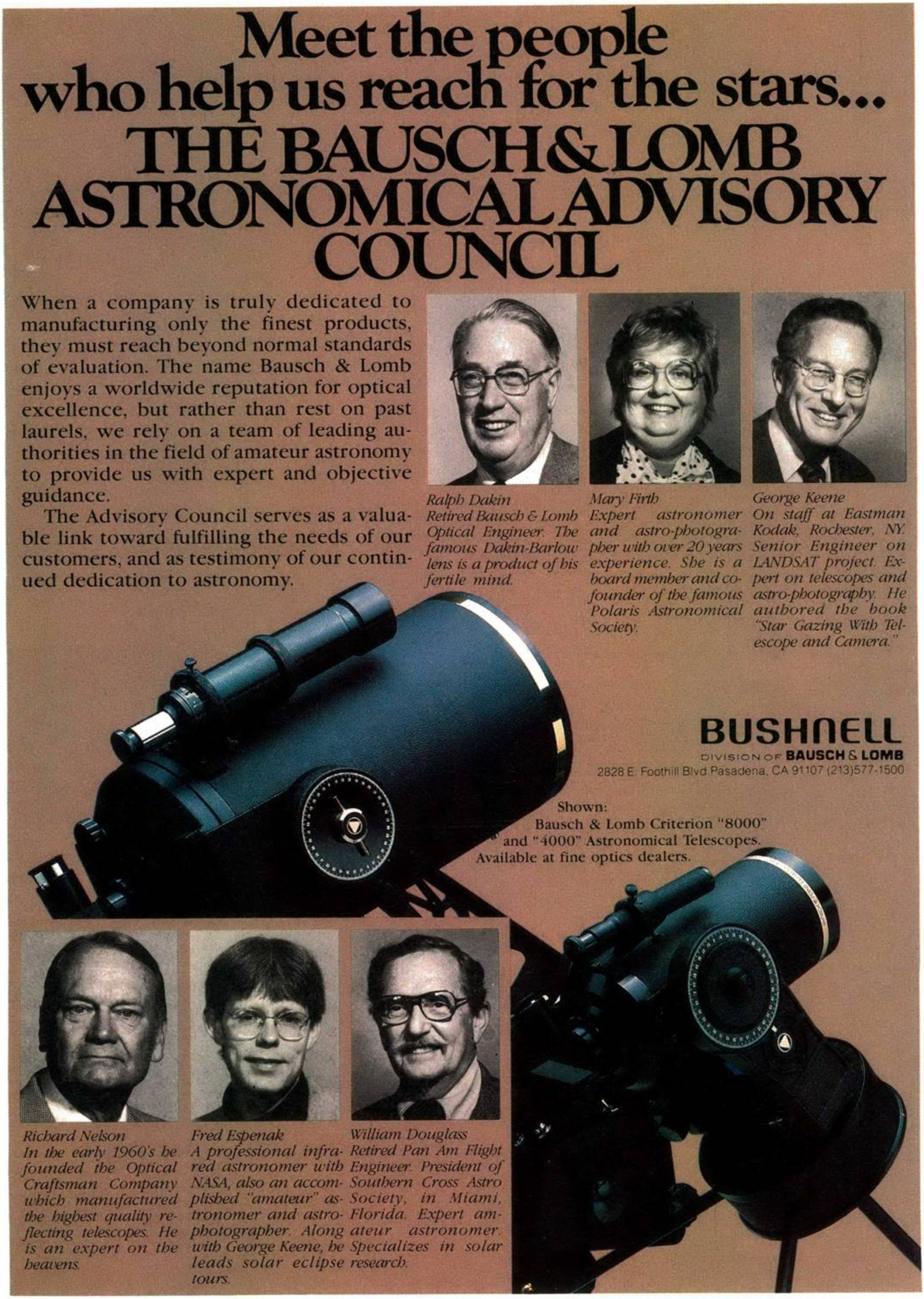
One astronomer did come forth to openly champion Jocelyn Bell's role in the discovery of pulsars — British astronomer Sir Fred Hoyle. In a letter to the London *Times* in April 1975, Hoyle voiced his belief that Bell should have been recognized with Hewish in the Nobel prize. Hoyle's criticism was directed toward the awards committee and not Hewish. "It seems clear that the committee did not bother itself to understand what happened in this case," he wrote.

Hoyle asked the pertinent question: Which is more important, the discovery by Bell or the follow-up investigation by Hewish? He answered this question by proposing that if the pulsar had been announced at the time of its discovery, other better equipped observatories would have proceeded with the follow-up investigation. Hoyle claims that the secrecy of the discovery was used to Hewish's advantage.

"There has been a tendency to misunderstand the magnitude of Miss Bell's achievement because it sounds so simple — just to search and search through a great mass of records," Hoyle wrote. "The achievement came from a willingness to contemplate as a serious possibility a phenomenon that all past experience suggested was impossible. Bell had recognized that the source changed its position from day to day at the same rate as the stars, showing that the source was celestial." Hoyle cited this as the key that unveiled the mystery — he wrote that "nothing that happened from then on could have made any difference to the eventual outcome."

Does the astronomical community subconsciously think Jocelyn Bell should have received credit in the award of the 1974 Nobel Prize? It is impossible to look into the minds of astronomers, but it is possible to view their written expressions as a key to their thinking. No one would accuse the astronomical community of an overt conspiracy in its treatment of the pulsar discovery. But at the same time, no one would deny that there is something controversial in the treatment.

George Reed
Westchester State College
Westchester, PA



Meet the people who help us reach for the stars...

THE BAUSCH & LOMB ASTRONOMICAL ADVISORY COUNCIL

When a company is truly dedicated to manufacturing only the finest products, they must reach beyond normal standards of evaluation. The name Bausch & Lomb enjoys a worldwide reputation for optical excellence, but rather than rest on past laurels, we rely on a team of leading authorities in the field of amateur astronomy to provide us with expert and objective guidance.

The Advisory Council serves as a valuable link toward fulfilling the needs of our customers, and as testimony of our continued dedication to astronomy.

Ralph Dakin
Retired Bausch & Lomb Optical Engineer. The famous Dakin-Barlow lens is a product of his fertile mind.

Mary Firth
Expert astronomer and astro-photographer with over 20 years experience. She is a board member and co-founder of the famous Polaris Astronomical Society.

George Keene
On staff at Eastman Kodak, Rochester, NY. Senior Engineer on LANDSAT project. Expert on telescopes and astro-photography. He authored the book "Star Gazing With Telescope and Camera."

BUSHNELL
DIVISION OF **BAUSCH & LOMB**
2828 E. Foothill Blvd. Pasadena, CA 91107 (213)577-1500

Shown:
Bausch & Lomb Criterion "8000"
and "4000" Astronomical Telescopes.
Available at fine optics dealers.

Richard Nelson
In the early 1960's he founded the Optical Craftsman Company which manufactured the highest quality reflecting telescopes. He is an expert on the heavens.

Fred Espenak
A professional infrared astronomer with NASA, also an accomplished "amateur" astronomer and astro-photographer. Along with George Keene, he leads solar eclipse tours.

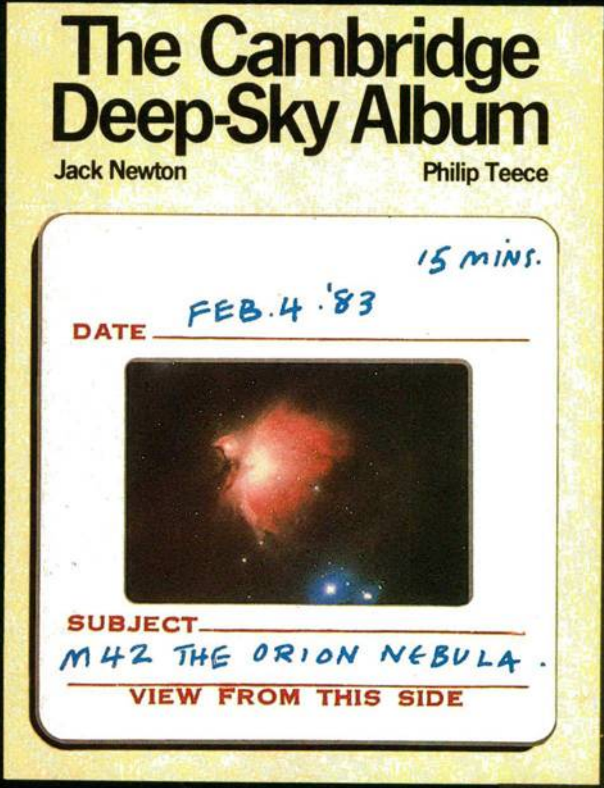
William Douglass
Retired Pan Am Flight Engineer. President of Southern Cross Astro Society, in Miami, Florida. Expert amateur astronomer. Specializes in solar research.

Just Published!

Experience the Thrill of Deep-Sky Observing with

THE CAMBRIDGE DEEP-SKY ALBUM

by Jack Newton and Philip Teece



M8 The Lagoon Nebula
NGC 6523
Diffuse nebula in Sagittarius
RA 18h 02m
Dec −24° 23′
Mag 6.0

On a clear, moonless summer night, if one looks at a point in the southern sky about 6 degrees north of the star γ Sagittarii, one may detect even with the unaided eye the dim, unfocused glow of the Lagoon Nebula. A small telescope reveals much of this magnificent object's splendour: its sparkling star cluster (NGC 6530), its pale billows of nebulosity and the dark void of the obscuring dust lane across its centre.

M8, one of the greatest of the H II (ionized hydrogen gas) regions in our galactic neighbourhood, is a complex object. The star cluster appears to heat a dense molecular cloud that lies behind it. The very compact, black 'globules' that lie in the foreground, silhouetted against the glow of the H II region, are believed to be cosmic material far advanced in the gravitational collapse that gives birth to new stars. NGC 6530 itself is believed to be a cluster of some of the youngest stars known; probably as recently as two million years ago they were, themselves, dark globules that had not yet become luminous.

The two brightest field-stars, prominent in the telescopic view of M8, are 9 Sagittarii and Herschel 36. These are not relatively nearby foreground objects, but highly energetic stars associated with the nebula itself; they have been identified as the principal sources of illumination of the surrounding nebulosity.

The Lagoon's distance is a matter of some uncertainty. The Royal Astronomical Society of Canada's *Observer's Handbook* cites a distance of 4500 light-years. *Burnham's Celestial Handbook* accepts the evidence for a much remoter position, about 5200 light-years away from our solar vicinity. If the latter estimate is used, the Lagoon is an enormous interstellar cloud, about 100 light-years wide. On this scale, the full diameter of our solar system is one hundredth that of the smallest dark globules observed in the Lagoon.

Imagine having a powerful telescope at your command, sweeping the skies in search of distant galaxies and nebulae, searching out the secrets of the heavens. **The Cambridge Deep-Sky Album** brings you all this and more — limited only by your imagination. Through the magic of modern astrophotography, you'll observe the delicate blue in the arms of spiral galaxies, the stunning deep red of glowing hydrogen nebulae, and the silvery glitter of star clusters strewn across the sky.

The Cambridge Deep-Sky Album is also a valuable companion for serious observers. Use it to plan observing sessions, or take it with you to the telescope. Its 136 color plates — taken by Jack Newton with his 16" reflector on cold-camera chilled Ektachrome 400 film — are benchmark standards of fine astrophotography. The description accompanying each plate gives every observer the background necessary to appreciate the true grandeur of celestial wonders seen in the eyepiece.

Send me____copy(ies) of **THE CAMBRIDGE DEEP-SKY ALBUM.**
Enclosed is my check for $_______.

Name

Address

City State Zip

AB-11-2

To order, send this coupon or a copy to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202 — or use the handy AstroMedia order form bound into this magazine.

- **136 beautiful images — all in color**
- **authoritative text with each plate**
- **includes galaxies, nebulae, and star clusters**
- **each object identified by M- and NGC- numbers**
- **each image enlarged to uniform scale and orientation**

THE CAMBRIDGE DEEP-SKY ALBUM

only **$19.95**

Foreign orders add $1.50.

ODYSSEY

Reach Into The Depths Of The Universe

and save hundreds of dollars with your choice of a powerful Odyssey Telescope

Enjoy the proven performance of these precision telescopes with the breathtaking ability to reveal the universe. Lower priced than many telescopes having only a fraction of their capability, the Odyssey series brings you the universe like no other.

See the colors of the Orion Nebula, the dust lanes in the Andromeda Galaxy, the elusive Veil Nebula, thousands of NGC objects and intricate lunar and planetary detail.

WE IMPROVED THE WAY YOU SEE THE UNIVERSE

The sturdy, stable Odyssey series is still unbeatable for aperture size, price and optical quality. And we still lead the way with dramatic new concepts which have revolutionized amateur observer telescopes.

SIZE. Odyssey telescopes offer you mirror diameters which let you get serious about exploring distant galaxies. You can now see the universe up-close as it really is.

PRICE. We offer low-priced telescopes of remarkable quality, and we sell the precision optics which go into them to observers who build their own instruments.

PRECISION OPTICS. Every Odyssey mirror optic is tested to beat anything in the field for brilliant, quality imagery.

EXPERIENCE THE UNIVERSE IN VISUAL HIGH-FIDELITY

Don't settle for less. Odyssey shows you a visually equalized universe-the correct size-to-brightness relationship of all objects viewed through a telescope.

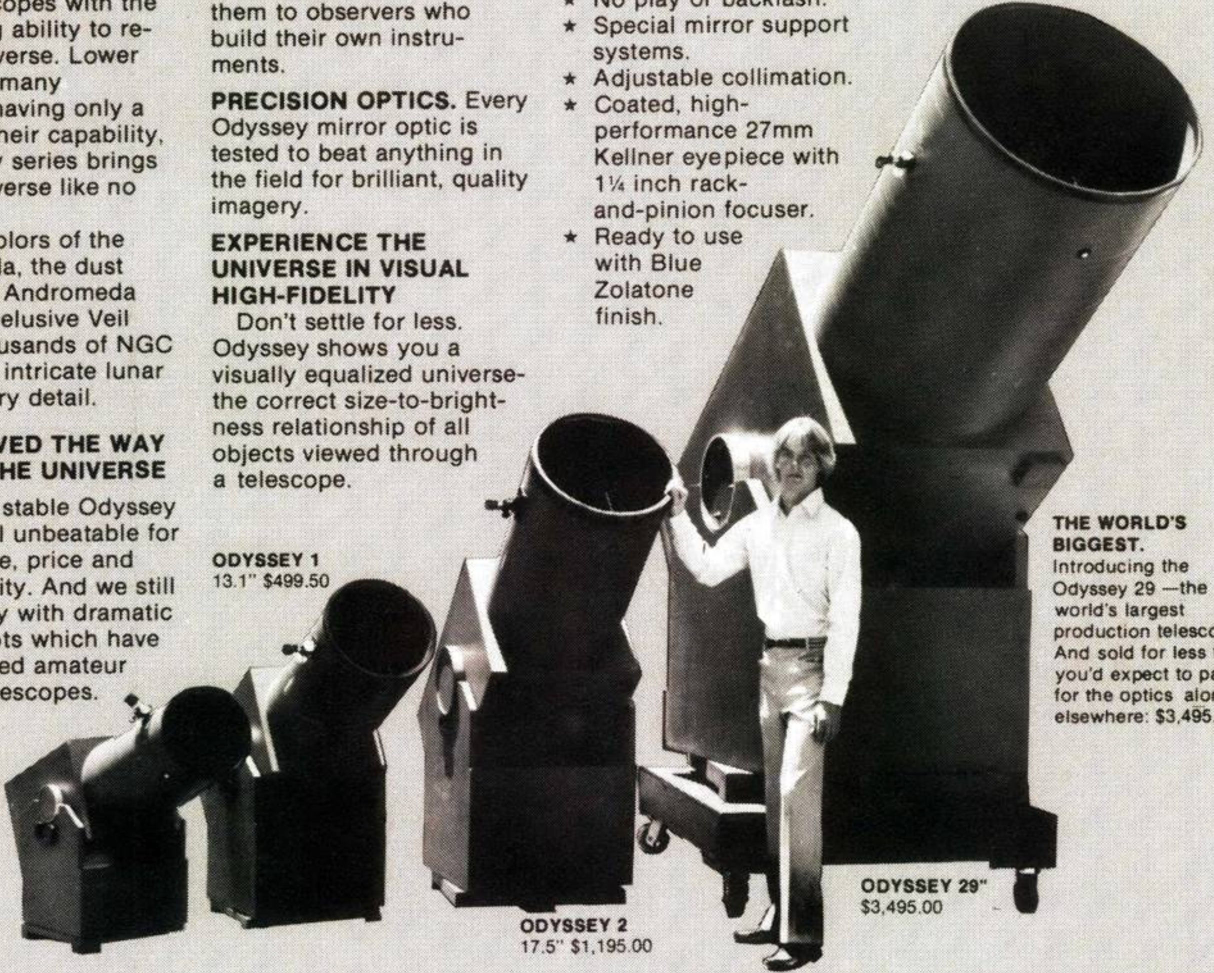
SPECIFICATIONS

All Odyssey telescopes feature:

- ★ Paraboloidal Pyrex mirror, null figured to ⅛th wave, aluminized & overcoated.
- ★ Super smooth and stable Dobsonian alt-azimuth mount with Teflon bearings throughout.
- ★ No play or backlash.
- ★ Special mirror support systems.
- ★ Adjustable collimation.
- ★ Coated, high-performance 27mm Kellner eyepiece with 1¼ inch rack-and-pinion focuser.
- ★ Ready to use with Blue Zolatone finish.

(Shipping charge payable upon delivery, F.O.B. Idyllwild, CA. Prices include crating. California residents — please add 6% sales tax.)

There's lots more available - for free literature on Dobsonian telescopes and parts write us immediately.



ODYSSEY COMPACT
10.1" $299.50

ODYSSEY 1
13.1" $499.50

ODYSSEY 2
17.5" $1,195.00

ODYSSEY 29"
$3,495.00

THE WORLD'S BIGGEST. Introducing the Odyssey 29 —the world's largest production telescope. And sold for less than you'd expect to pay for the optics alone elsewhere: $3,495.

DOBSONIAN Headquarters

Large Aperture Lightweight Mirror Optics

The emphasis is on performance with these truly revolutionary lightweight mirror optics. You now can build the light, compact large aperture telescope you have always wanted.

Mirrors can be mounted as standard, flat-back or on flotation cells. There are complete instructions with these null figured, ⅛ wave paraboloidal Pyrex mirrors. All are aluminized and over-coated, free of astigmatism, with approximately 13-1 diameter-to-thickness ratios. Your satisfaction is guaranteed.

Massive Observatory-size Optics

29 inch f/4.5 mirror	$2490.00 16-1 Ratio
17.5 inch f/4.5 mirror	$ 659.50 13-1 Ratio

Now you can see virtually every NGC object. Faint, undefinable shapes appear in startling detail. Includes diagonal.

Lightweight Mirror Optics at Low, Low Prices:

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
12.5 inch f/4.5 mirror	$259.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50

SHIPPING: Optics prices include shipping in the 48 contiguous states. Shipping to other destinations is additional.

Pyrex Mirror Blanks for Dobsonian Telescopes—Diamond Edged

10 inch x 1⅛	$ 49.50
12.5 inch x 1⅛	$ 79.50
13.1 inch x 1⅛	$ 89.50
17.5 inch x 1 5/8	$249.50
20 inch x 1 5/8	$395.00
22 inch x 1 5/8	$495.00
24 inch x 1 5/8	$750.00
29 inch x 1 5/8	$899.00

Elliptical Diagonals

These coated flats are ready to mount and use. This wide selection is low priced. Guaranteed 1/10 wave. Select the minor axis you need:

1.83" — $15.50
2.14" — $18.95
2.60" — $22.50
3.10" — $34.50
4.25" — $69.50
6.25" — $150.00

Visit our showroom at
54141 Pinecrest Road
in Idyllwild, one of California's
premiere mountain resort
communities

Coulter Optical Co.
the ODYSSEY Telescope people
Dept A-1 P.O. Box K
Idyllwild, CA 92349

We welcome your call:
(714) 659-4621

VISA

California residents add 6% sales tax please

ASTRONOMY
IN FOCUS

Microcomputers in Astronomy

Sir / Dennis Chamberland wrote an excellent article on astronomical applications of home computers in the August issue. I both agree and disagree with several of his points.

I agree that there is a lot of misinformation about personal computers. Who needs a computer to balance a checkbook? Or to file recipes? These are solutions looking for a problem. But I disagree with Mr. Chamberland's suggestion that home computers be used to compute the position of Io, the times of sunrise and sunset, or planet ephemerides. All of these are available in *The Astronomical Almanac* for under $20 per year — a far cry from the $4,000 for a reasonably well-equipped home computer.

The other applications he mentions are very good uses for a home computer. Although few, if any, home computers can execute the kind of ray trace programs used by professional optical designers, the programs that are available for home computers do represent a giant step forward for amateur opticians.

For those wishing to use their personal computers to control the position of their telescopes, Mr. Chamberland sounds very discouraging. Actually, the situation is not all that bad. Andrew Tomer of Pasadena, California, has successfully connected his Apple computer to his trailer-mounted 12" Cassegrain. Using surplus parts, it is possible to provide all the necessary hardware for connecting a telescope to a computer for about $1,000, although it is much quicker to use commercially available cards and hardware, and the result is more reliable.

Mark Trueblood
Potomac, MD

Editors' reply: The point made by Mr. Chamberland was not that you should purchase a home computer for calculating a jovian satellite ephemeris, but rather that if you have bought a computer already, why not do so? Also, given the current "state of the art," connecting a telescope to a computer requires more tinkering know-how than many of today's computer-purchasers have, or care to learn. But as you imply, things will probably get much easier in the near future.

Sir / The article by Dennis Chamberland rightly underlines the natural affinity between positional astronomy, which is essentially mathematical, and the computer, whose foremost application lies in number-crunching.

Though the author warns the prospective buyer that a computer cannot set up his telescope, wash his car, or walk his dog, he would like us to believe that writing one's own programs is the only way to build a useful program library. Well, things are not just that simple! Granted, learning the basics of BASIC takes only a few hours, but the proficiency needed in most astronomical applications will take much longer to acquire.

Let me give you an example: Many versions of BASIC are precise only to the tenth digit (two or three digits less than a good calculator), and it takes some fancy programming skills to be able to retain the required accuracy. Then, after you've acquired some programming skill, you'll still need to learn enough positional astronomy (celestial mechanics) to know what it's all about. In short, don't think you will buy a home computer today and start writing fancy astronomical programs next month.

My suggestion is that you buy a book with program listings (like Eric Burgess's *Celestial BASIC*) and try to understand how the programs work. Once this is achieved, you can always tailor them to suit your needs. Faster still is to buy ready-made astronomical programs on cassette or diskette. They are more expensive, but will give you the satisfaction of using your computer right away — although there is the problem of getting one that runs on your machine.

Pierre Brind-Amour
Nepean, Ontario

Military Space

Sir / While one can argue, as do Robertson and Pike (Forum, April 1983 and February 1982), about how much each nation is doing, it is clear that both superpowers are proceeding with the militarization of space. For many of us spaceflight has represented something noble and hopeful, but increasingly this hope is being betrayed.

Indeed, an even graver betrayal is occurring.

The tool-making genius of humans has made us an extraordinarily successful species. Some anthropologists would even say that while we made tools, the tools made us — shaping our bodies and minds. But today this genius is turning against us, for we just can't stop dreaming up new weapons. The weapons become ever more complicated and expensive and dangerous — more than dangerous enough to destroy civilization — but we can't stop inventing them.

Now the new environment of space makes possible a mass of new weapons, and all the signs are that we will rush to build them. This in turn suggests that the tool-making genius that made us so successful will now destroy us, for there is little hope that we can get away with this indefinitely.

Some people, including our political leaders, are satisfied that the arms race has brought four decades of "peace," but those of us whom astronomy has taught to think in larger terms know that this species — us! — has a chance to live four billion years. When we measure four decades of rickety, hysterical "peace" against four billion years, it seems hopeless.

The dream of spaceflight, of a human future as large as the stars, has turned into a nightmare.

Don Lago
Columbia, MO

Light Pollution Woes

To all amateur and professional astronomers:

You know that light pollution is one of the biggest problems we observers face today. Well, I'm trying to do something about it here in Miami, but I need your help. I need information: facts, figures, statistics, feasability studies from other areas — anything that will help me accomplish my goal.

Thank you for your attention and your help.

Olga M. Gonzalez
4590 West 9 Avenue
Hialeah, FL 33012

Sir / I would like some help from fellow readers. I live in a rural area that once provided plenty of darkness for pursuing my astronomy hobby.

However, problems have arisen linked to the electric co-op company that serves my area and their installation of security lamps on my neighbors' lots. The electric company furnishes poles and lights, which turn on and off automatically, for $5.00 a month. The electric company refuses to shield the lights in any way. When I tried to talk to them about it, they told me that if I was inconvenienced that was too bad.

My neighbors, when approached about shielding, laughed at me because they want more light, not less. These lights are now springing up all over the neighborhood.

Have any readers experienced this problem? What recourse is available? Can legal action be taken and if so, under what grounds? Is literature available concerning the detrimental nature of light? If so, where can it be obtained? Has anyone approached you with the idea of an association to lobby against indiscriminate use of light?

Ray Santiso
7 Sun Drive
Rockwall, TX 75087

Satisfaction!

Sir / Tonight I feel an intense satisfaction, astronomically. Using my 6-year-old 40mm refractor on a rickety little table tripod, on a stool perched atop a picnic table, I have achieved a "grand slam": Jupiter and its Galilean satellites, Saturn with its rings, crescent Venus, and a Full Moon all came under my 50x gaze tonight.

I hope all those sky watchers with binoculars or low-power scopes can get some encouragement from this. Big things can happen with little instruments. Good seeing to you all!

Joel Alvin Christine
Tyrone, PA

Sirs / I live in a rather light-polluted city, but have excellent dark skies an hour away. The answer to my observing needs has been two small-aperture telescopes.

I have an excellent 80mm refractor, which gives unsurpassed views of the Sun, Moon, planets, and double stars, and fair views of the brighter deep-sky objects, from my backyard. The image contrast of the refractor really helps in light-polluted areas, but the instrument is too heavy to be moved easily.

For deep-sky observing, I have a 90mm Maksutov of a popular brand. I mount it on a light but sturdy photo-tripod; its setup time is seconds. It takes up very little space in a small car.

While not really good for higher powers, at 40x and lower it gives surprisingly good views of many objects. Most globulars aren't resolved, but they're seen well, perhaps as Messier saw them. Many galaxies, open clusters, and nebulae are easily found and are quite pleasing in this scope.

The two telescopes together cover a lot and demonstrate that small scopes can be effective.

Dan Dunn
Portland, OR

Ooops!

As a star becomes a red giant, its luminosity *increases*, not decreases, as stated on page 75 of "FG Sagittae: One Piece of the Puzzle" in the October issue.

behind
the scenes

meet the stars

The word "star" no longer means what it used to. If you don't believe me, stop somebody on the street and ask if they know any of the stars. Chances are they'll say, "Heck, no — I've never even been to Hollywood." So much for modern civilization and the degradation of our language.

Real stars happily greet anyone who looks up at night. Real stars are among the most enduring features of our entire world. Even though the woods I used to walk through as a child have been bulldozed and the town I grew up in has become unrecognizable, the stars I learned when I was ten are still the same. In fact, they'll still be pretty much the same tonight — for me — as they were for Ptolemy and Tycho, or Herodotus and Hevelius.

A few centuries ago the stars played a bigger role in people's lives. They were familiar, always present. There wasn't as much to do at night. If you went outside at night, you found your way by starlight or moonlight. And there were fewer man-made lights to brighten the sky — the very fact that Messier discovered his deep-sky objects from downtown Paris testifies amply to that.

And those curious forms, the constellations, that we see among the stars, and the myths and legends that Fred Schaaf discusses every month in Eye on the Sky — those are stories that often date to times before we humans wrote things on clay, papyrus, parchment, paper, or silicon. Tonight you can connect with humanity's past by stepping outside and seeing Orion stride across the sky, one arm upraised with a club, the other holding a shield against a charging Bull. How quaint! We don't fight with clubs or defend ourselves with shields nowadays.

Today many of us must make a substantial effort just to see the stars — finding a spot where streetlights won't shine in our eyes, where no one will laugh at the weirdo looking into the sky, where the glow of miles of golden arches, all-night this-and-thats, billboards, and area floods don't obscure all but a few.

Do *you* know the constellations? Would you recognize Orion if you opened the front door and looked in the sky? Have you shown your spouse, son or daughter, or any friends the kind of stars they probably *don't* recognize, the stars that don't have publicity agents or collect a million dollars per film? They're there, you know, waiting for you to discover them.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

HIGH PERFORMANCE TELESCOPES

ASTROPHOTO OF THE MONTH

Spiral Galaxy M-33 in Triangulum. This low surface brightness galaxy is seen best visually with a LUMICON DEEP-SKY Filter. Photo by Dr. Jack Marling using a LUMICON Newtonian EASY-GUIDER and 2415 film sensitized in a LUMICON Model 300 HYPER-KIT; 40 min. exposure, 10"f/5 telescope.

TELE VUE™ EYEPIECES USE THE BEST!!

Plossl, Wide-Field, Nagler Eyepieces

Tele Vue Plossl eyepieces have a sharp 50° apparent field-of-view. The Wide-Field eyepieces have a 65° field-of-view and are sharper than Erfle and Konig Eyepieces. The revolutionary Nagler eyepieces are sharp clear to the edge of a giant 82° field-of-view. **The eyepiece is half the telescope — use the best!**

7.4, 10.4, 13, 17, 21, 26mm Plossl **$55**
2½X **Tele Vue Barlow** Lens **$55**
32mm Plossl, widest true field in 1¼" .. **$70**
55mm 2" Plossl, widest possible field . **$150**
19mm Wide-Field, 1¼" eyepiece **$100**
24mm Wide-Field, "superb" **$115**
32mm Wide-Field, 2" eyepiece **$185**
40mm Wide-Field, "awesome" **$240**
4.8mm Nagler, 82° field **$125**
9mm Nagler, 82° field, "the best" **$175**
13mm Nagler, 82° field, 1¼" or 2" **$200**

SUPER-FINDER™

The LUMICON SUPER-FINDER is both a compact Rich-Field Telescope and a magnificent "Super-Finder". It has a fully coated 80mm achromatic lens and 300mm focal length. The Deluxe SUPER-FINDER has a superb 500mm f/6 air-spaced lens.

10X80mm SUPER-FINDER, with 30mm 1¼" eyepiece **$149.95**
SUPER-FINDER w/o eyepiece **$129.50**
IMPORTANT: Select 1¼" or 2" straight-through or right-angle viewing. Right-angle version requires a star diagonal.
DELUXE SUPER-FINDER w/o eyepiece (requires 1¼" or 2" star diagonal) **$199.50**
1¼" star diagonal, 30mm aperture .. **$26.95**
2" LUMICON mirror-type star diagonal, threaded for 48mm filters .... **add $89.50**
Mounting rings, 3-5/8" I.D **$16.95/pair**
Mounting adapter for C-8, Meade etc ... **$35**

NEW! SUPER C-8, MEADE 2080LX

Special Prices for these systems end Dec. 31, 1983

Super Precision Byers Worm Gear Drive
• Precision Optics, Hand-Matched and Certified

HIGH PERFORMANCE 8" TELESCOPE SYSTEM (Super C-8 Shown) **$1250**

Includes your choice of a **Meade 2080LX** (dark blue) or **Super C-8** (black) 8"f/10 telescope system. List price value = $1620. Includes a high precision worm gear drive system ideal for astrophotography (5-10 arc second periodic error), high transmission coatings, 8X50mm right-angle finderscope, equatorial wedge, heavy-duty Meade adjustable Field Tripod, accessory tray, dew shield, no-tool knob set, special eyepieces, and accessories. Shipping added ($20-$40) for charge orders.

OPTIONS BOOST PERFORMANCE

Starbright enhanced silver coatings boost visual transmission 10-15% (C-8 only) .. **$98**
LUMICON® Premium UHC Filter .. **add $79**
LUMICON® **Cassegrain EASY-GUIDER** Rich-Field Viewer ($216 value) ..... **add $198**
LUMICON Rich-Field Viewer **$99**
Deluxe Piggyback Mount, adjustable **$39.50**
200mm f/3.5 superb multicoated lens **$99.50**
Electric Declination **$88**
Dual-Axis Drive Corrector for astrophotography (joystick control) **$160**
Quartz Dual-Axis Drive Corrector **$240**

HIGH PERFORMANCE 8" TELESCOPE SYSTEM (Meade 2080LX Shown) with optional LUMICON Cassegrain EASY-GUIDER and 200mm f/3.5 Piggyback telephoto lens.

2" LUMICON Mirror-Type Diagonal, new compact lightweight design, threaded for 48mm filters. Black anodized **$99.50**
With 1¼" eyepiece adapter **$108.50**
2" viewing adapter for C-5, C-8, C-11, C-14, Meade 2080, 2040, 2120, Dynamax-8 . **$19.95**
50mm Plossl 2" eyepiece **$79.95**
Rich-Field Viewer: 2" star diagonal with 1¼" adapter, 50mm Plossl 2" eyepiece and C-8 viewing adapter ($209 value) **$185**

LUMICON® FILTERS STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter™** improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter™** is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	**UHC**	**Deep-Sky**
For 0.965" eyepieces	—	**$49.95**
For 1¼" eyepieces	**$79.50**	**$59.50**
48mm for 2" eyepieces	**$119.50**	**$99.50**
For 2" eyepieces & photography		**$99.50**
Set, 1¼" UHC & Deep-Sky Filters		**$119.50**
Selected premium filters		**add $20**

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	**$29.95**	**$25.00**
52, 55, 58, 62mm	**$39.95**	**$29.95**
67, 72, 77mm	**$46.95**	**$39.95**
82mm	**$49.95**	

Hypered 2415 film, 36 exp ... **$9.95** ... **3/$27**

LUMICON®
2111 Research Drive #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add $8 ($20 for HYPER-KITS).
California Residents add 6% tax.
Prices subject to change w/o notice.

DEEP-SKY ASTROPHOTOGRAPHY

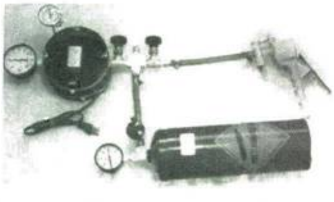
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer*, but it easy to use. Not recommended for 2415......... **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$275.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$299.50**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$265.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*

†Patent Pending

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".
NEWTONIAN EASY-GUIDER **$139.50**
3X Relay Diagonal [See Photo] **$59.50**
Illuminated reticle eyepiece system . **$59.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$199.50**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**
GIANT EASY-GUIDER **$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] ...... **add $79.95**

WHAT DO YOU NEED?

1. Hypersensitized Film. Use a LUMICON HYPER-KIT to insure a fresh supply, or use film pre-sensitized by LUMICON.
2. Illuminated reticle eyepiece system & battery pack, dual crosslines **$59.50**
3. Telescope with good drive. (See above)
4. Piggyback adapter (state telescope type)...**$25** Deluxe adjustable **$39.50**
200mm f/3.5 multicoated lens **$99.95**
5. Filtration is essential for all lenses. Use hypered 2415 and the H-Alpha Pass Filter. For III a-J or color, use the Minus Violet Filter or the LUMICON DEEP-SKY Filter.
6. Off-axis guider is **essential** for consistantly good prime-focus astrophotography.
7. Dual-axis drive corrector and electric declination (state telescope type) **$259**

Kodak technical pan film 2415
TP 135-36
400
Kodacolor VR
1000
12

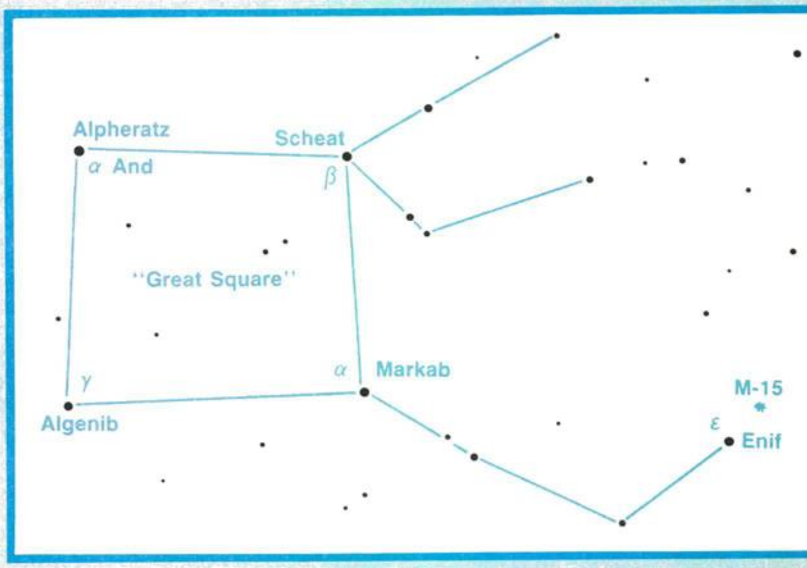
HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. For fine grain B&W film use 2415. The fastest color films are Fujichrome 400 for slides and Kodak VR1000 for prints. Use VR1000 for galaxies and Fujichrome 400 for nebulae.

Film Type (35mm unless marked)	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens	36	**$9.95**
Ektachrome 200 prof. 5036	20	**$9.95**
Fujichrome 400, "Excellent"	20	**$12.95**
III a-J B&W for galaxies	20	**$12.95**
VR1000, fastest of all, color negs	12	**$12.95**
5072, color slides from negs	36	**$6.95**
D-19 B&W Developer, 1 gal.		**$5.95**

exploring the winter constellations

by
Earle F. Dodds



Although it is most prominent during the lengthening skies of autumn, the Great Square of Pegasus still dominates a portion of the winter sky. It contains the bright globular cluster M-15.

It's 8 p.m. on December 1. Huddled in a blanket, sprawled out on your chaise longue with cup of steaming coffee in hand, you look skyward. From your dark location, stars of the winter Milky Way — Orion, Taurus, and Perseus — rise up from the east with a bright sparkle; the Summer Triangle sinks into the west, reminding you of warmer times. You hold a small pair of binoculars toward some of the bright points in the sky; they gleam with different colors, different brightnesses, different personalities. Then you scan the entire winter sky with just your eyes and discover that hundreds of suns — and a few fuzzy patches of light — are scattered across the heavens. You see things you never realized were there. The sky is a multitude of luminous points, but where are the many constellations you've heard about? Where is Canis Minor? The diminutive form of Triangulum? The twisting arc of Eridanus? The eye of Taurus the Bull?

Sit back, relax, and let your eyes adjust to the darkness. Tonight you'll see all of the winter constellations and a few of the most prominent in spring and fall skies. They contain plenty of bright stars — all nearby fellow travelers in our Milky Way Galaxy — and a sprinkling of more distant objects such as star clusters, nebulae, and galaxies.

Setting low in the west is the Summer Triangle, the summer sky's most imposing figure, composed of the bright stars Deneb, Vega, and Altair. Deneb (α Cyg) is the brightest star in Cygnus the Swan and marks the top of the cross formed by the constellation's stars. North of Deneb is a faint patch of light visible to unaided eyes under dark skies; this is M-39, an open star cluster. With binoculars, you'll see a patch of blue-white stars about as large as the Full Moon. The base of the cross is Albireo (β Cyg), in binoculars a close pair of blue and yellow stars. Vega (α Lyr) is the brightest star in Lyra the Lyre, a small bright group that contains an interesting double star, Epsilon (ε) Lyrae. The brightest sun in Aquila the Eagle is Altair (α Aql), a bluish-white star.

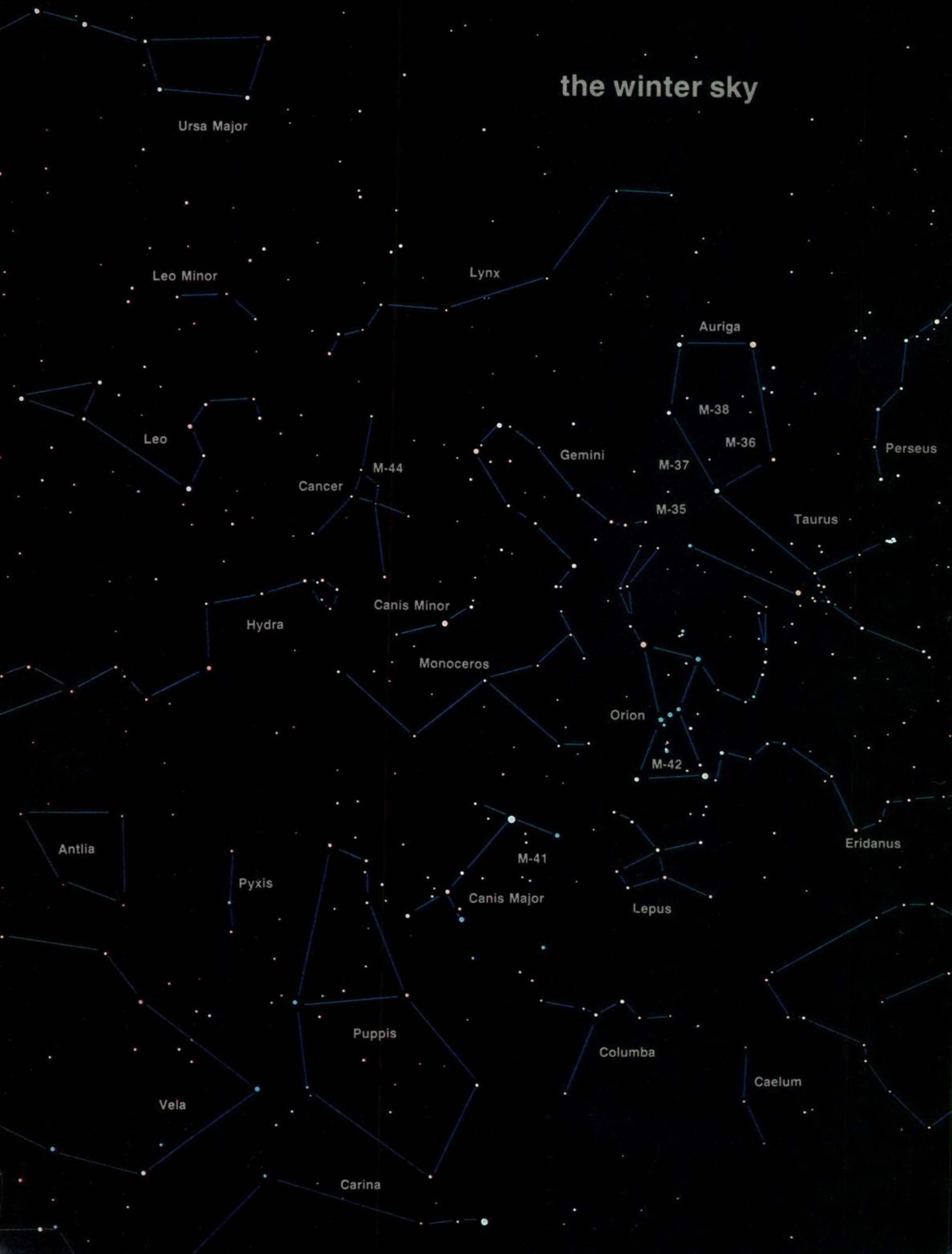
Toward the southwest you'll see a lone bright star, Fomalhaut (α PsA), a prominent autumn star belonging to Piscis Austrinus, the Southern Fish. Aquarius (the Water-Bearer) and Capricornus (the Sea Goat), each an arrangement of moderately faint stars, lie north of this lone star.

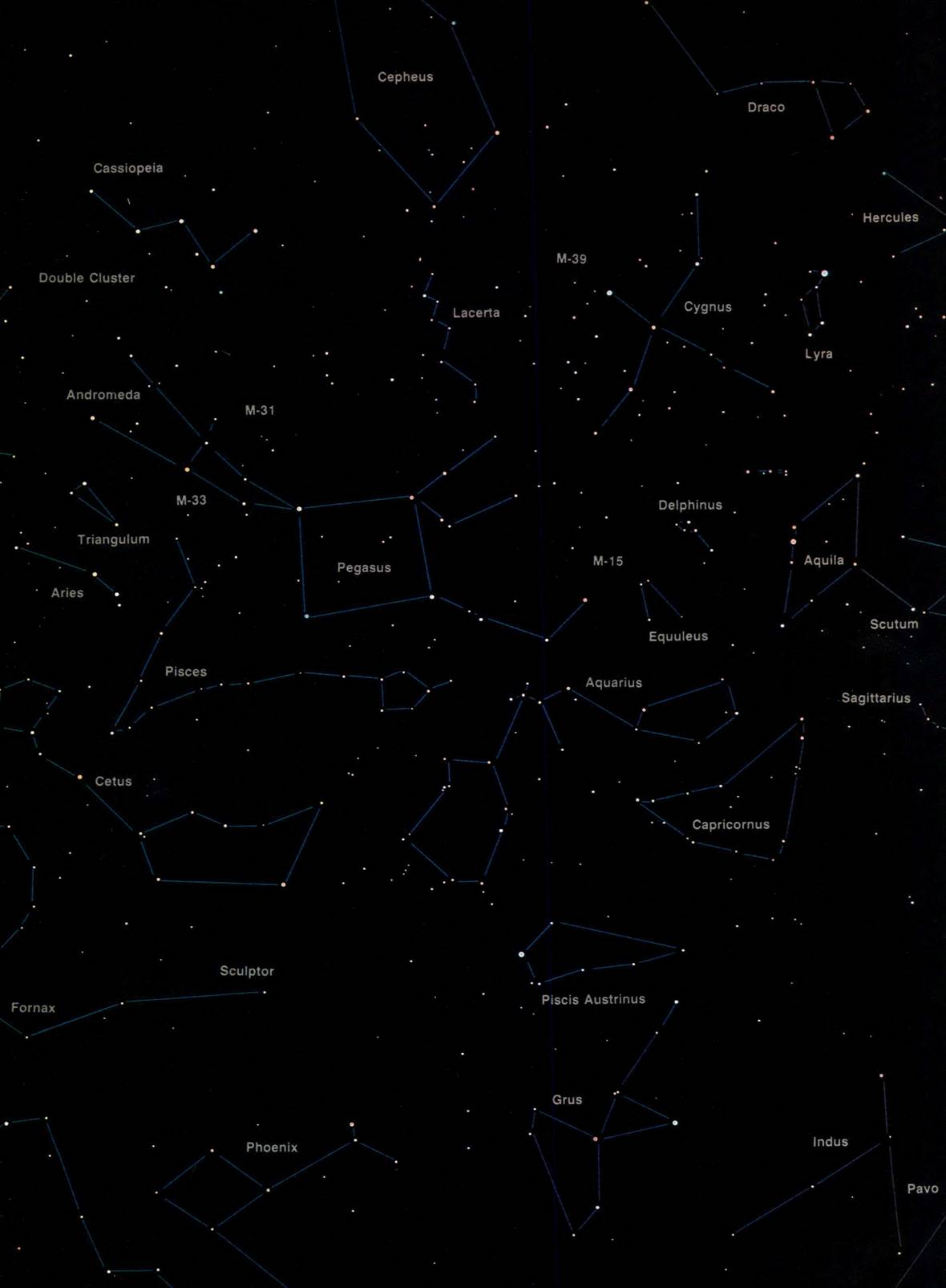
Just west of the zenith is a conspicuous asterism consisting of four bright stars formed in a rectangle. This is the Great Square of Pegasus, the main body of the Flying Horse. It is not exactly square, however, and contains one star — Alpheratz (at top left) — that actually belongs to Andromeda. Aside from the Square there is not much more to Pegasus other than a kind of "tail" that stretches westward from Markab to the second-magnitude star Enif, a little more than the distance between Markab and Algenib, and almost in line with them. Near Enif is a small globular star cluster, M-15, visible in binoculars as a fuzzy spot of light. Another, much larger, fuzzy patch of light is M-31 in neighboring Andromeda. This is the Andromeda Galaxy, at a distance of 2.2 million light-years the most distant object visible to the naked eye. A mnemonic for finding M-31 from Alpheratz is "two over and two up." If you have clear, dark skies you'll see the huge patch, which spans five times the Moon's diameter. Andromeda itself is composed of two parallel strings of bright stars; the lower begins at Alpheratz (α And) and ends at Almach (γ And), a triple star too close to be resolved with binoculars.

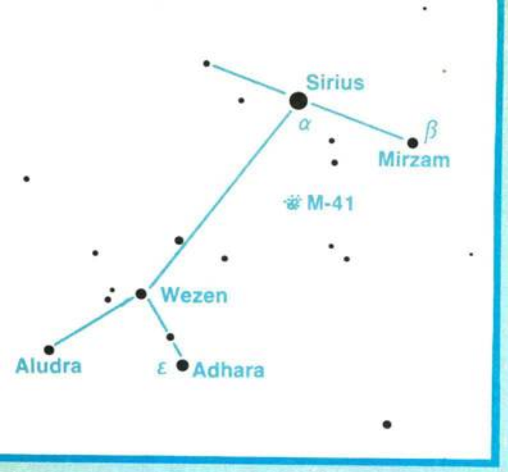
Something you can see in binoculars is the faint galaxy M-33 in the tiny constellation Triangulum. Later, when you start using a telescope, you'll want to "collect all of the M-objects" — this one will give you fits. It is large, but its light is so spread around that it is elusive. Don't be discouraged if you can't find it.

Continuing southward from Andromeda through Triangulum we come to Aries the Ram, whose brightest star — Hamal (α Ari) — is the only bright feature in the area. Aries is a small group of stars, but Pisces the Fish, just west of it, is a huge, looping arc of stars. It is a zodiacal constellation, one which lies along the apparent path of the planets. Not a conspicuous group —

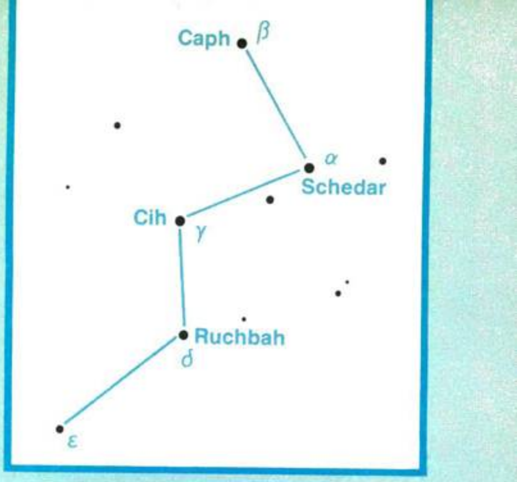
the winter sky


Ursa Major
Leo Minor
Lynx
Auriga
Leo
M-38
M-36
Gemini
Perseus
M-44
M-37
Cancer
M-35
Taurus
Canis Minor
Hydra
Monoceros
Orion
M-42
Antlia
M-41
Eridanus
Pyxis
Canis Major
Lepus
Puppis
Columba
Caelum
Vela
Carina

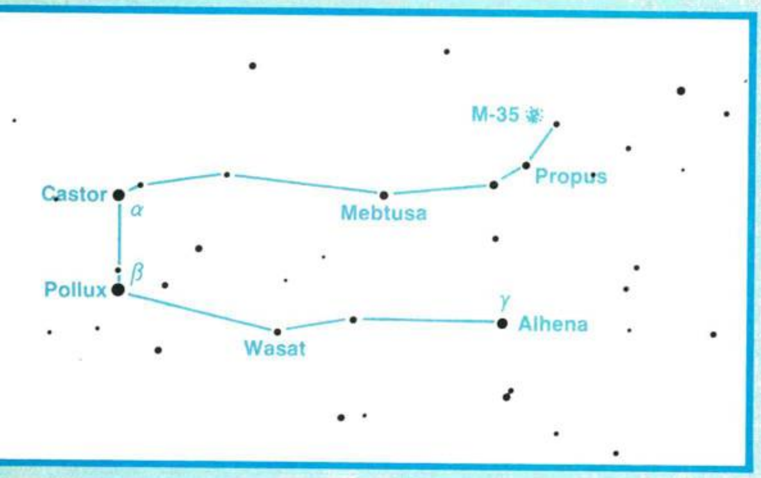

Cepheus
Draco
Cassiopeia
Hercules
M-39
Double Cluster
Cygnus
Lacerta
Lyra
Andromeda
M-31
M-33
Delphinus
Triangulum
M-15
Pegasus
Aquila
Aries
Scutum
Equuleus
Pisces
Aquarius
Sagittarius
Cetus
Capricornus
Sculptor
Fornax
Piscis Austrinus
Grus
Indus
Phoenix
Pavo



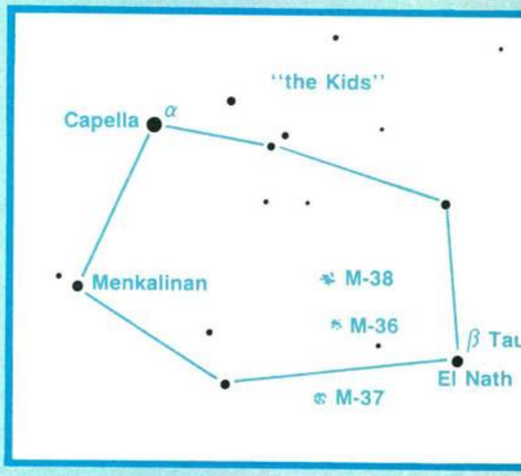
The brilliant glow of Sirius, the brightest star in the heavens, easily shows off Canis Major. The Great Dog also holds M-41, a bright cluster.



Now high in the northwest is the "W" shaped figure of Cassiopeia the Queen.



The twin bright stars Castor and Pollux help outline the rectangular form of Gemini. Use binoculars to see star cluster M-35.



Auriga the Charioteer contains Capella, the sixth brightest star in the sky, and the three binocular star clusters M-36, M-37, and M-38.

none of its stars are brighter than third magnitude — it contains a notable asterism called the "Circlet," which lies just under the Great Square of Pegasus and represents one of the two fish in the star group; the other lies near Triangulum.

Immediately south of Aries and Pisces sprawls Cetus the Whale, which contains only one bright star, Diphda. Although it is only a second-magnitude star, Diphda stands out because it is isolated. Cetus also has a famous variable star — Mira — which fades and brightens. During about a year's time, Mira erratically changes between 3rd and 10th magnitude — going going from an easy naked-eye star to one that is invisible without binoculars. See if the star shows up well when you observe the southerly constellation. The head of Cetus, off to the east, is marked by a third-magnitude star, Menkar.

If you live deep in the south, you may be able to see the star Achernar, the southern end of Eridanus the River, which rises up near Rigel in Orion and winds all over the heavens. Achernar, whose name means "End of the River," is one of the brightest stars in the southern sky. Omicron^2 (o^2) Eridani is a lovely binocular double star.

Now look northward and you'll see a sprawling "M" shape — the constellation Cassiopeia the Queen. The two brightest stars in the M are Caph (β Cas) and Schedar (α Cas). Caph is the westernmost star, and Schedar the one next to it. Six months from now Cassiopeia will appear below the pole; it will then look like a "W." Between Cassiopeia and the pole is Cepheus the King, an inconspicuous group of stars that looks something like an old-fashioned church with a steeple; at this time of year, though, the asterism is lying horizontally rather than standing upright.

Halfway between Cepheus the King — a far northern group of faint stars — and Scheat in the Great Square is the small and inconspicuous constellation Lacerta the Lizard. It contains no bright stars and does little else than occupy some of the space between Cepheus and the Square.

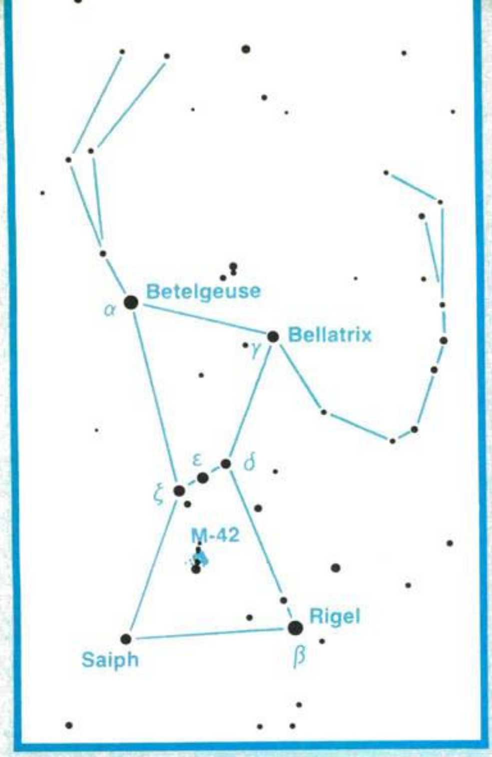
Now it's time to turn your lawn chair around to the east. Midway between Cassiopeia and Andromeda and just east of them is the constellation Perseus. The brightest star in the constellation is Mirfak, set in a region of scattered blue and white stars. South of Mirfak is Algol, a variable star that "winks" — fades by a magnitude — once every 69 hours. See if you notice its change after a few nights of stargazing. A fine binocular object in Perseus is the so-called Double Cluster, halfway toward Cassiopeia and visible to unaided eyes as a faint glow. Binoculars show twin grainy clusters, packed with tiny stars. Farther east, the "Winter Hexagon" — a huge asterism that contains parts of Auriga, Gemini, Canis Minor, Canis Major, Monoceros, Orion, and Taurus — is now above the horizon. There is practically nothing else of much interest in the eastern sky.

Almost overhead is the constellation Auriga the Charioteer. Although this group is easy to see, it doesn't look anything like a man in a chariot. It is marked by the golden-yellow star Capella (α Aur), and also by two asterisms. The main asterism is a striking pentagon; the smaller one is a triangle of third-magnitude stars near Capella. This little triangle bears the name "the Kids," supposedly representing three baby goats held by Auriga. Capella is the sixth brightest star in the sky, and it is closer to the pole than any of the other really bright stars. In fact, its close proximity to the pole allows most North Americans to see it at some time every night of the year!

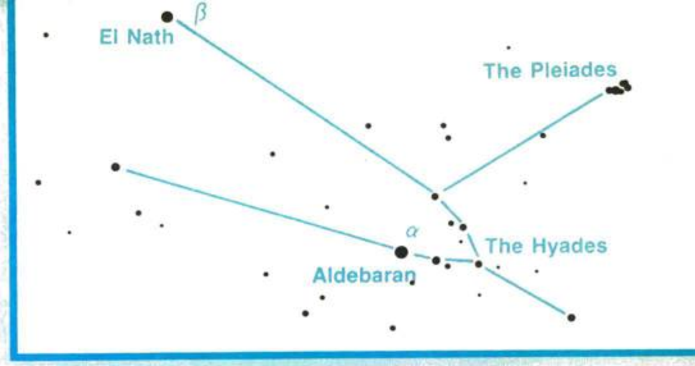
Within the pentagon lie two bright binocular star clusters, M-36 and M-38. Both are open clusters, but they are too far apart to be called "double." A third cluster, M-37, lies just outside the southeastern side of the pentagon. All three appear as areas of tiny stars peppered onto the black background, as if someone had spilt celestial salt. These objects lie in the plane of the Milky Way, but Capella lies just outside it.

Farther east lies a pair of twin stars of approximately equal brightness, about as far apart as the pointers in the Big Dipper. They are Castor (α Gem) and Pollux (β Gem), the two brightest stars of Gemini the Twins, a zodiacal constellation. This is a large bright constellation; it too contains a binocular open cluster — M-35 — located near its "feet."

Far south of Gemini is the bright star

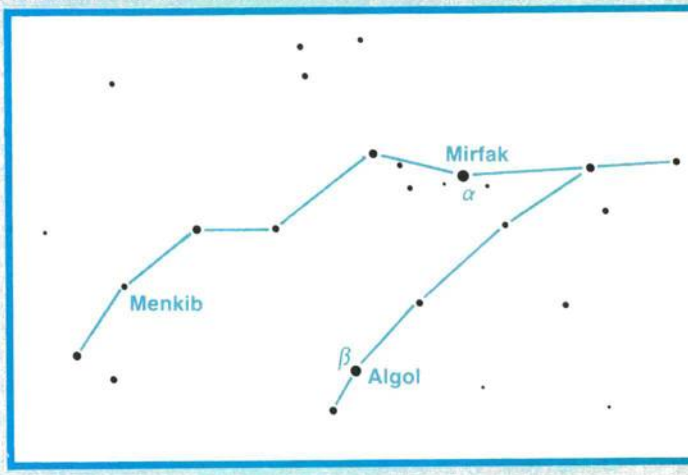


Orion the Hunter is the brightest constellation in the winter sky. It holds the bright nebula M-42, in the Hunter's "sword."



Many of the stars representing Taurus the Bull belong to two nearby open clusters, the Hyades and the Pleiades.

Perseus the Hero is composed of many bright white and blue-white stars, including variable Algol — the "demon."



Sirius (α CMa), the "Dog Star." The brightest star in the entire sky, it is so conspicuous that you can't mistake any other star for it. About midway between Pollux, of the Twins, and Sirius is another bright star, Procyon (α CMi), the "Little Dog Star." Just as Capella and Pollux define a side of the winter hexagon, Pollux and Procyon define one, and Procyon and Sirius define a third. West and a little north of Procyon is another brilliant star, Rigel (β Ori). Rigel is slightly brighter than Procyon but not as bright as Capella. Rigel and Sirius define the fourth side of the hexagon. Still moving north and west, we come to the red star Aldebaran (α Tau) in Taurus, the "eye of the bull." Aldebaran is the sixth star in the celestial polygon. If you join it with Rigel and also with Capella, you complete a giant hexagon with very bright stars at each corner. The hexagon ties together six constellations — Auriga, Gemini, Canis Minor, Canis Major, Orion, and Taurus.

Ruddy Aldebaran is embedded within a group of stars called the Hyades, a large V-shaped asterism that is actually a nearby open star cluster. Although Aldebaran is apparently in the group, it actually lies much nearer to us. The horns of zodiacal Taurus the Bull are tremendously long, both stretching out 20° or more. The northern horn ends with the star El Nath (β Tau), a member of Taurus but nevertheless used to indicate the pentagon of Auriga. The Pleiades, also known as the Seven Sisters, appears as a tight luminous grouping of six to seven stars — some people see as many as 11 without optical aid — and is one of the most stunning sights in the winter sky. Look at the group with your binoculars: the light you see has traveled for 410 years; you see the cluster as it was when Galileo first trained his telescope on the stars.

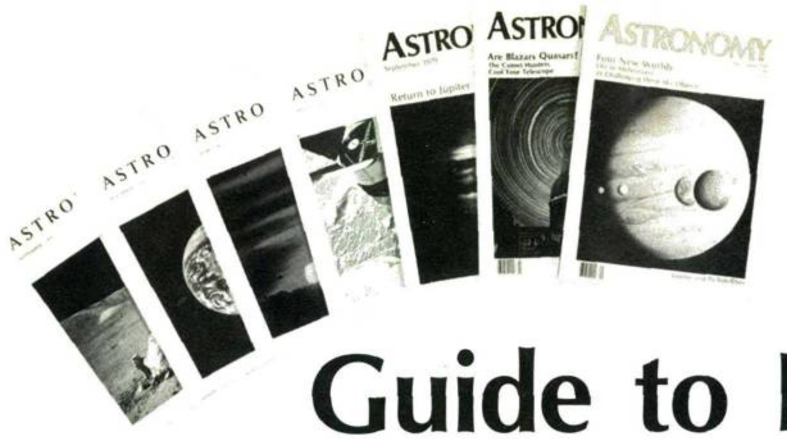
Adjacent to Taurus is the brightest and most striking constellation of the winter skies — Orion the Hunter. The bright blue-white star Rigel marks the left foot, reddish Betelgeuse (α Ori) is at his right shoulder, Bellatrix (γ Ori) is at his left shoulder, and the three stars Alnitak (ζ Ori), Alnilam (ε Ori), and Mintaka (δ Ori) mark his belt. One of the most famous objects in the sky is Orion's Great Nebula, located in the handle of his sword, which hangs down below the belt stars. Composed of two Messier objects — M-42 and M-43 — the Great Nebula is a region of hydrogen gas condensing into hot young stars. Visible as a hazy patch of light to the naked eye, the greenish ghostly appearance of this gas cloud shows up well in binoculars.

Immediately below Orion is the constellation Lepus the Hare. This group of stars contains little of interest; its brightest star shines at third magnitude and is called Arneb, Arabic for "rabbit." Another faint group of stars is Monoceros the Unicorn — just east of Orion — whose brightest star is only a fourth magnitude dot of light. This group is barely visible on some nights and holds little of interest to naked-eye watchers.

Looking around to the east, it's now late enough for some of the spring constellations to peek above the horizon. Stretching high above Auriga is the dim group called the Lynx, whose brightest star is also a third-magnitude object. Lynx ends above an asterism called the "Sickle," which looks like a backward question mark. This is the head of zodiacal Leo the Lion, and contains the blue-white star Regulus — named "Little King" by Nicholas Copernicus.

Just beginning to swing downward is the Big Dipper, the principal asterism in Ursa Major the Great Bear — but alas, the Big Dipper is a spring star group. We'll explore more of the sky in the upcoming parts of this series. For now you've spent a night exploring the winter constellations. You've seen Auriga the Charioteer, Orion the Hunter, Taurus the Bull, Gemini the Twins, many bright stars and a few faint mysterious patches of faraway light. You now know that the sky is not at all a mysterious place, but a familiar one — and indeed that is the first step to take in discovering the nature of the universe and, more important, your place in it.

Earle F. Dodds's earliest astronomical observation was of Halley's Comet in 1910. He made his first telescope in 1926 and has spent many thousands of hours under the constellations since then. His last article in ASTRONOMY was "Image Orientation," in the April 1981 issue.



Back Issues
Back Issues
Guide to Back Issues

DOES YOUR ASTRONOMY LIBRARY NEED UPDATING?

Did you miss our coverage of the historic first launch of the Space Shuttle *Columbia*? Are you looking for a Telescope Buyer's Guide? Did our coverage of Voyager 2 at Saturn make you curious about Voyager 1 at Jupiter? Did your subscription start just *after* our 3-part series on building a Dobsonian telescope? Would you like to catch up on computers in astronomy? If you missed these or any other exciting issues of ASTRONOMY, here's your chance to complete your collection.

To order, print the month and year of those you want on the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202. Please list the issues in order by date. Add $3.00 for orders to Mexico & Canada, $3.50 other foreign.

— $4.00 —

August 1973: FIRST ISSUE. Hour of the Midday Night (solar eclipses), In Search of Planet X

May 1975: The Search for Intelligence, Exploration from Space

June 1975: From Dust to Dust (stellar evolution), The Changing Surface of Mars, Rich Field Telescopes

July 1975: The Quest for Life on Mars, The Age of Nearby Stars, Mysteries of the Galactic Core

August 1975: Faster Than Light?, Observing the Perseids, The Great Red Spot

September 1975: Baptism of Fire, The Quasar Dilemma, Let's Take a Look at the Sun, Building a Solar Projection Screen

October 1975: Starspots on Betelgeuse, Shape of the Milky Way, Observing Jovian Detail

November 1975: Big Bang to Galaxy, Mars' New Frontiers, Find a Comet

December 1975: Astronomy from the Moon, The Planet Mercury, Stellar Beehive

— $3.50 —

February 1976: Io, Exploding Stars, The Gibbous Moon

March 1976: Beyond Space Shuttle, Infrared Astronomy, Life's Protective Shield (magnetic field reversal)

April 1976: Finding Unseen Worlds, Dust Clouds and Ice Ages, Your Most Valuable Equipment (Your Eyes)

May 1976: Quasars: Oddities of Space, Cosmic Explosions, Molecules of Life, Choosing B&W Films, Observing Galaxies

June 1976: Asteroids, Viewing the Full Moon, What You Can See Through a Small Refractor

July 1976: SPECIAL ISSUE (32 extra pages!) The History of American Astronomy. Complete from prehistory through Palomar

August 1976: Venus, Clusters of Galaxy Clusters, Exploring the Milky Way, Part 1, Red Light Sky Photography

September 1976: MOON ISSUE. The Moon's Early History, Science on the Moon, The Last Quarter Moon, Developing B&W Astrofilms

October 1976: Radio Interferometry, Searching for Mars on Earth, Birthplaces of Stars, Star-Test Your Telescope

November 1976: The Space Telescope, Black Holes, White Holes and Wormholes, Doubles, Binaries and Multiple Stars, Schmidt Cameras

December 1976: The Magellanic Clouds, Printing Your Astrophotographs, Part 1, The Messier Catalog, Cleaning Your Telescope Mirror

---

January 1977: MARS ISSUE. Viking on Mars: Exciting Results, Life on Mars: Ambiguous Results, Printing Your Astrophotographs, Part 2, Exploring the Milky Way, Part 2

February 1977: Uranus and Neptune, Pluto, Miniblack Holes, Cold Cameras, Part 1

March 1977: Phobos and Deimos, New Color Photos of Galaxies, Cold Cameras, Part 2, Binoculars for Stargazing: Part 2, Observing from the City

April 1977: Supernovae!, Printing Your Astrophotographs Part 3, Building a 6" Reflector, Part 1, Observing the Outermost Planets

May 1977: The End of Time, Can Life Evolve in Elliptical Galaxies? Building a 6" Reflector, Part 2

June 1977: Gamma Rays and the Origin of Cosmic Radiation, Observing with Binoculars

July 1977: The X-Ray Universe, What Makes Novae Blow Up?, Astrophotography with Telephoto Lenses, Tracking Asteroids

August 1977: Slow Boat to Centauri, Building a 6" Reflector, Part 3, Assembling Your Telescope

September 1977: Stars With Companions, Robot Probes, Building a 6" Reflector, Part 4, Light Pollution

October 1977: MARS ISSUE. The Polar Regions of Mars, Buyers Guide to Small Telescopes, "Red Variable" Stars

November 1977: The Revolution in Astronomy, The Southern Sky

December 1977: Why Do Planets Have Rings? Tunguska, Learning the Constellations, Part 1, Printing Your Astrophotographs, Part 4, Tuning in on Radio Astronomy

— $3.00 —

January 1978: Our Sun, Photographing the Sun in H-Alpha, Observing Herschel Objects, Building a 6" Reflector, Part 5

February 1978: Why Does Earth's Climate Change? Photograph the Moon!, What You Can See Through a 6" Telescope

March 1978: Swarms of Stars: Cosmic Calibrators, Rival Cosmologies, Isophote Mapping, What's Inside Your Telescope, Part 1

April 1978: Beyond Centauri, Brown Dwarfs and Black Holes, What's Inside Your Telescope, Part 2, Learning the Constellations, Part 2

May 1978: Terraforming, Blink for a Nova!, The "Big Four" Asteroids, Celestial Software, Right Ascension and Declination

June 1978: Astronomical Spectroscopy, Solar Eclipse '79, Astrophotography — With Camera Only!, Gravity, Dust and Solar Neutrinos, Naked Eye Astronomy, Part 1

July 1978: Red Dwarf Stars, What's Inside Your Telescope, Part 3, Are Galaxies Here to Stay?, Celestial Software, Telling Time, Learning the Constellations, Part 3

August 1978: EARTH ISSUE. The Early History of Planet Earth, Earth's First Oceans, What's Inside Your Telescope, Part 4, Naked Eye Astronomy, Part 2

September 1978: The Redshift Problem, The Dark Sky Paradox and the Origin of the Universe, Altitude and Azimuth

October 1978: Are Black Holes Really There?, Learning the Constellations, Part 4, Build Your Own Telescope

November 1978: ECLIPSE ISSUE. Asteroid Mining, Observing Earth from Space, Film the Eclipse!

December 1978: Pluto — Planet or Imposter?, U.K. Schmidt Pictorial, Watching the Inner Planets, Calculating Horizon Coordinates

---

January 1979: Are We the Only Intelligent Life in Our Galaxy?, Is There a New Lunar Crater?, Photographing Star Clusters, Hunt a Cluster

February 1979: Stellar Evolution, The Sun Will Darken!, Eyepieces: What You Get is What You See, A Revolution in Solar Physics

March 1979: Planetary Nebulae, Part 1, Nebular Filters, Patrolling the Planets

April 1979: Look Who's Moving into Our Neighborhood, Voyager Approaches Jupiter, Pioneer Venus First Results, Planetary Nebulae, Part 2

May 1979: A Voyage to Jupiter, The Great Midwinter Eclipse

June 1979: Gravity Wave Astronomy, The Moon: the Southern Highlands

October 1979: Buyer's Guide to Telescopes, The Top 21 Deep-Sky Objects, The Cosmological Principle

November 1979: Pioneer at Saturn, High Resolution Astrophotography, The Moon: Mountains, Basins, and Scarps, Mass Loss from Stars

December 1979: The Quasar Connection, Equipment for Observing the Sun, Tricolor Astrophotography

— $2.50 —

January 1980: Alien Eyes, Satellite Views of Earth, Wide-Field Sky Photography, Was Einstein Wrong?

February 1980: Southern Skies Explored, A (Sad) Tale of Two Comets, Cool Your Telescope, Are Blazars Quasars?

March 1980: The Colors of Deep Space, The Cooling Fire of Creation, Photographing the Sun, Building a Sundial

April 1980: Return to the Moon, What Accessories Do You Really Need?, Using SO-115 Film

May 1980: The Colors of Mars, Asteroids: The Flying Mountains, The Afro-Indian Shadow Connection, An Album of Galaxies, Sunspots

June 1980: Cosmic Contamination, KAO: Mission Incredible, How to Build a Dobsonian Telescope, Part 1

July 1980: The Great Red Spot, Mysterious Pluto, Stalking the Gaseous Nebulae, How to Build a Dobsonian Telescope, Part 2, The Puzzle of SS-433

August 1980: Journey to the Center of the Galaxy, Constellations of the Milky Way, How to Build a Dobsonian Telescope, Part 3, Extraterrestrial Climate Threats

September 1980: Four New Worlds (Jovian Satellites), 21 Challenging Deep-Sky Objects, A Darkroom for Astrophotography, What's My F-Ratio?, The Lively Meteorites

October 1980: Why All the Fuss About Quasars?, How to Buy a Telescope for a Child, Getting the Most from Your Deep-Sky Negatives, Space, Time and Black Holes

November 1980: An Imaging Revolution (Electronics), Universe: Time Zero, North American Solar Eclipses: The Next 50 Years, Processing Your Astronegatives

December 1980: Of Transits and Timeballs, Keeping Warm While Stargazing, The Moon: Ring Mountains and Walled Plains

---

January 1981: Voyager 1 at Saturn, Winter Hunting, Observing Planets in the Daytime, Making Astroprints

February 1981: Voyager: Science at Saturn, Cold Camera for Astrophotography, All About Telecompressors, Observing Peculiar Galaxies.

March 1981: Venus by Radar, Observing Gas Giants, Bare-Bones Astrophotography, Solar Magnetism

April 1981: The Tektite Controversy, Mining a Meteor Crater, Hypersensitizing, Part 1, All the Angles on Magnification, Image Orientation, The Fallen Sky

May 1981: The Solar Maximum Mission, The View from Io, The Moon: Rilles and Wrinkle Ridges, Hypersensitizing, Part 2, The Invisible Universe

June 1981: Probing the Chemistry of Galaxies, Observing Planetary Nebulae, Getting the Correct Exposure, Flare Stars

July 1981: Mars: 5 Years After Viking, The Electronic Sky, July's Lunar and Solar Eclipses, The Age of the Universe

August 1981: Space Shuttle, Watch for the Meteors, Beginner's Guide to Telescope Types, Saturn Update

September 1981: Mr. Halley's Hairy Star, The Pleasures of Deep-Sky Observing, Handcrafted Homebuilt Telescopes, The Infrared Universe, Part 1

October 1981: The Star Clouds of Magellan, 1981 Telescope Buyer's Guide, Starting an Amateur Astronomers Club, The Infrared Universe, Part 2

November 1981: Voyager 2 at Saturn, Observing for Pleasure — Urban Astronomy, Cold Camera vs. Gas Hypering, Stellafane and the Art of Telescope Making

December 1981: The Saturnian Moons, Is That Lens a Star Performer?, Paint the Night Sky on Your Ceiling, The Search for Extrasolar Planets

— $2.00 —

January 1982: The Three Suns of Centaurus, Making the Most of Black-and-White Astronegatives, Equatorial Platforms, Caution! High Winds Beyond this Point

February 1982: The Galileo Mission to Jupiter, Cameras for Astrophotography, How to Reduce Tracking Error, A Closer Look at Saturn's Rings

March 1982: Secrets of Interstellar Clouds, How to Plan a Newtonian Reflector, The 2415 Revolution, The Molecules Between the Stars

April 1982: The Incredible Skies of Mauna Kea, Do Supernovae Trigger Star Formation?, Alt-Azimuth Setting Circles, Bloopers, Alien Skies.

May 1982: The Planets or Bust, Topography of the Terrestrial Planets, Making Black and White Slides, An 8-inch Telescope, The Glass Giant of Palomar

June 1982: The Electromagnetic Spectrum, Rethinking Your 60mm Refractor, How Much Sky Can My Camera Capture? The Vanishing Act of Carbon Giant

July 1982: Landscapes of the Solar System. Do You Really Need an RFT?, Revealing the Venusian Secrets

August 1982: Backtracking the Comets, Photographing the Home Galaxy, Easy Steps to Perfect Polar Alignment, STS-3

September 1982: Solving the Mysteries of Venus, Astronomy in the Garden, What Heats the Solar Corona?

November 1982: Looking Inside Quasars, Film Loading Tips, Galactic Coronas, 21 Objects for Binocular Observers

---

January 1983: To Sculpt the Galaxies, Space Art in Hawaii, A Mini-Observatory for Your Backyard, The Great 1983 Almanac Skychart

February 1983: Vesta: A World of Its Own, From Chaos to Consciousness, Capturing Deep Sky Objects on Paper, Backyard Photoelectric Photometry, Off-Axis Guiding

April 1983: Voyager to Uranus and Neptune, Venus Radar Mapping Mission, Sketching the Moon and Planets, How to Star Test Your Telescope, Infra-Red Astronomical Satellite

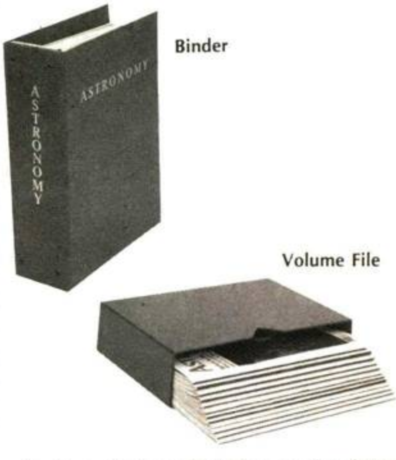
August 1983: Celestial Winds, Polar Lights, Comet Swift-Tuttle and the Perseids, 50 Finest Double Stars for a 60mm Refractor, Amateur Astronomy and the Home Computer

September 1983: Return to the Planets, Four Probes to Comet Halley, Total Solar Eclipse in Java, Short Focus Photography, X-rays from Stars, Binoculars and Binaries

October 1983: Daedalus: Design for a Starship, Decoding the Hertzsprung-Russell Diagram, Indonesian Eclipse Pictorial, FG Sagittae: One Piece of the Puzzle, 1983 Buyer's Guide to Astronomical Telescopes

November 1983: Geology from Space, The Tragedy of the American Space Program, Simple and Inexpensive Tricolor Photography, Studying Galactic Structure with Binoculars, Part 2

Protect Your Copies of ASTRONOMY



Custom-designed binders and volume files provide handsome protection for your collection. Looseleaf-style binder opens flat for convenient reading; issues slip in and out easily of box-style volume file. Each holds 12 issues.

Binder or Volume file. . **$6.95 each**
3 for $18.95; 5 for $28.95

All foreign orders add $2.50 per binder or volume file.

eye on the sky

venus and saturn in conjunction

by Fred Schaaf

the wanderers

The best planetary conjunction in several years occurs this month, topping the list of December's celestial offerings. Two bright planets will move to within 9 minutes of arc of each other at mid-month. The conjunction also hints at things to come, for a multi-planet arrangement will open the new year.

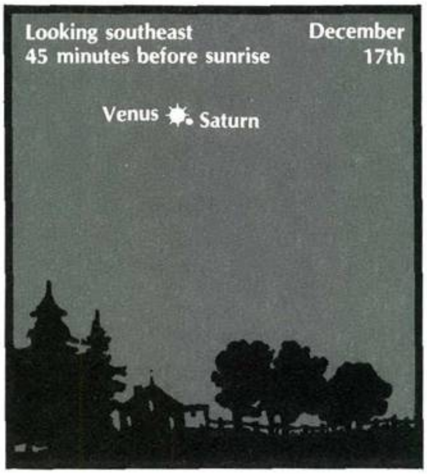
Five years ago, back in the summer months of 1978, first Mars and Saturn and then Venus and Saturn paired up for conjunctions so close that at first glance the planets almost seemed to be touching. This month, the objects will again be **Venus** and **Saturn**, only slightly farther apart than at their 1978 meeting and superbly placed for observing.

Although Venus and Saturn have rather southerly declinations (slightly unfavorable for most readers), they lie at 42° elongation from the Sun on the 17th, and rise for most of us about 3½ hours before the Sun. Thus the planets will be high in the sky long before the first traces of morning twilight.

And what a sight they'll be! The exact time of conjunction is about 5:30 a.m. Eastern Standard Time (about 10:30 UT), when Venus will be located just over 9 minutes of arc north of Saturn. The view from Britain and Europe a few hours earlier will be just as good; despite the relatively fast apparent motion of Venus, the planets will form a close pair on the mornings before and after the big event. Venus will be a yellow-white, −3.4 magnitude object, while Saturn will shine at magnitude 0.8, a golden pinpoint of light just below the "morning star." As if that weren't enough, blue-white Spica and red Mars (both somewhat fainter than Saturn) add to the scene, lying to the upper right of the paired planets.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

And the show will not be over when the morning twilight starts. The scene will make some fine pictures on film or in memory, especially if the sky fills with the gorgeous lavender and pink of a twilight enhanced by airborne volcanic ash. Then, as sunrise approaches, see when you can last detect Saturn. Also, try following Venus with your unaided eye until well after sunup.



Before twilight starts you may note the star Alpha (α) Librae just a few degrees southeast of Venus and Saturn. Binoculars will plainly show this star as a wide double — little more than twice as close as Venus and Saturn that morning. (The planets will be closer together than Mizar and Alcor.) The telescopic view of Venus and Saturn is discussed in The Backyard Astronomer.

The next Venus-Saturn conjunction as close as this one will occur in 1992, but it will not be as favorably placed for observation. And no conjunction of bright planets visible easily in a dark sky will be as close as this one for the rest of this decade. In short: Try not to miss these celestial ornaments as they hang together in the holiday sky!

In general, Venus is now moving lower in the sky, fading slightly as it does so. This is, however, only a moderate decline from the superb altitude and brightness it had over the previous few months. Saturn, on the other hand, is brightening and increasing its elongation as it creeps east into Libra. The planet is occulted by the Moon for parts of Europe on December 2 and for parts of North America on the 29th (see The Backyard Astronomer for details).

Two other interesting events will be visible to some readers. An annular eclipse on December 4 will be seen as a partial solar for much of Europe and Britain. These areas will also see a not-very-dramatic penumbral lunar eclipse on the 20th.

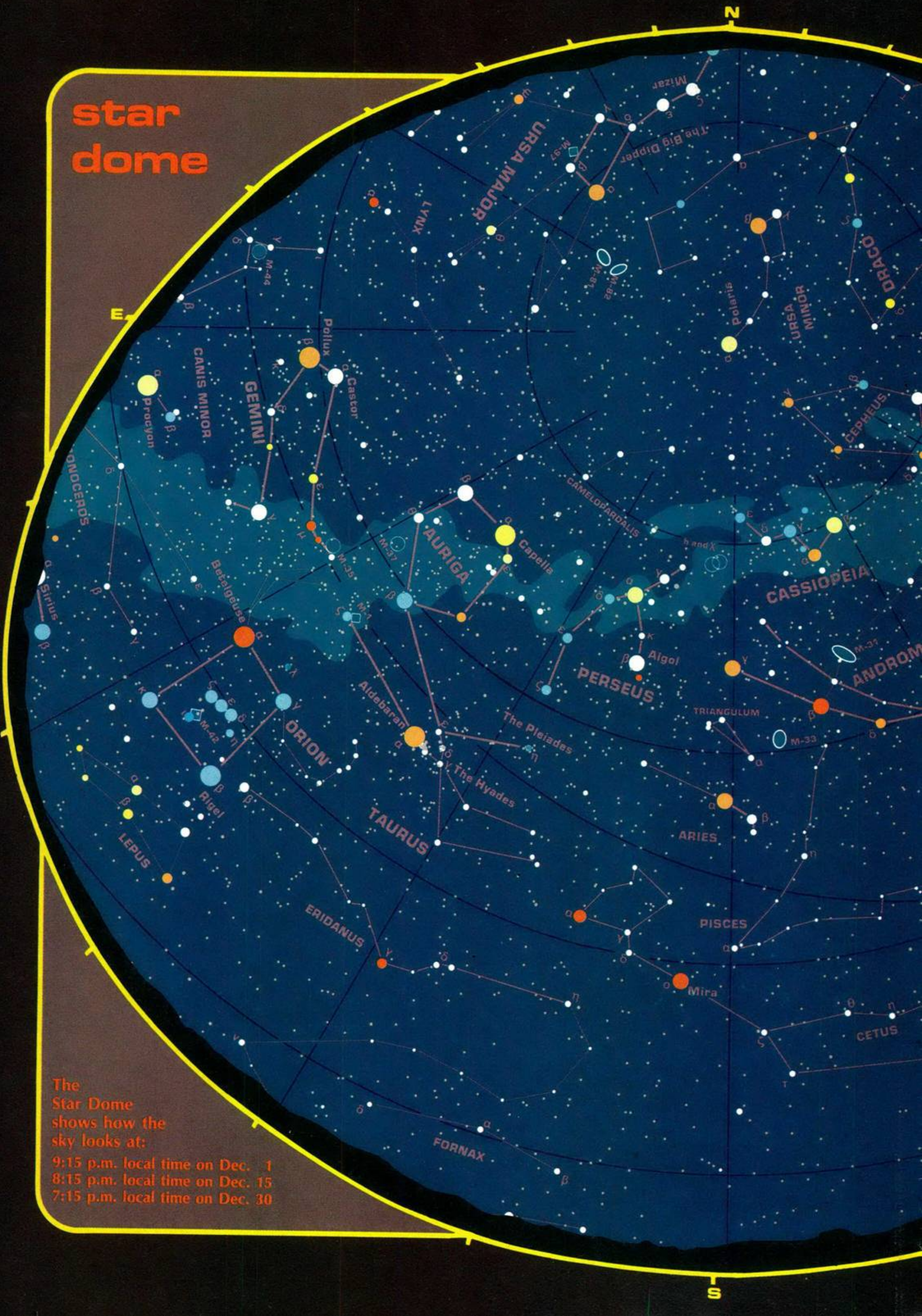
But what of the other planets this month? Some are very well placed, some very poorly. As already mentioned, this month **Mars** is sharing a place in Virgo with Spica, passing 4° north of the star on the 27th. Though Mars was at aphelion (farthest point in its orbit around the Sun) on November 30 — two days before Venus reaches perihelion — Earth now begins to catch up with the Red Planet. We'll see it brighten from about magnitude 1.7 to 1.4 during December. So it remains dimmer than Spica — but not for many weeks longer. The year 1984 will be excellent for Mars.

While Mars lies over 70° from Sol by the end of the month, **Jupiter** undergoes a conjunction with the Sun on the 14th, just reappearing in the pre-dawn sky (about 14° elongation) on December 31. The planets **Uranus** and **Neptune** are also in conjunction with the Sun this month, on the 2nd and the 21st.

The minor planet **Vesta** is at opposition

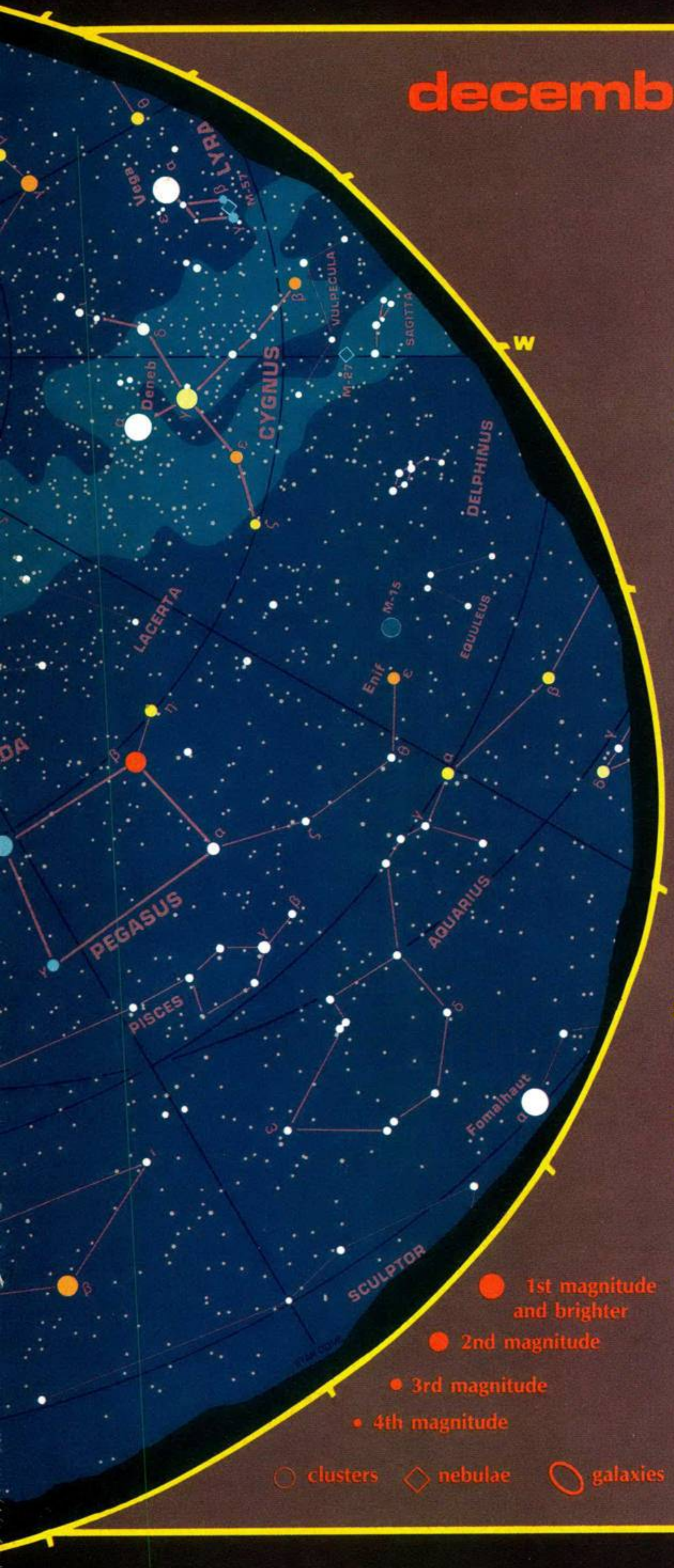
A young Moon joined Regulus, Saturn, and Venus in the great conjunction of July 1978. This month, Venus and Saturn pair up once again in another close conjunction. Mike Voisin, of Mount Pleasant, Michigan, used a 135 mm lens at f/3.5, 64-speed film, and an exposure of 5 seconds to make this shot.

star dome


N
E
S
URSA MAJOR
Mizar
The Big Dipper
M-97
M-81
M-82
LYNX
M-44
DRACO
URSA MINOR
Polaris
Pollux
Castor
GEMINI
CANIS MINOR
Procyon
MONOCEROS
CEPHEUS
CAMELOPARDALIS
h and χ
CASSIOPEIA
AURIGA
Capella
M-37
M-35
M-1
Sirius
Betelgeuse
PERSEUS
Algol
M-31
ANDROMEDA
TRIANGULUM
M-33
ORION
M-42
Rigel
Aldebaran
The Pleiades
The Hyades
TAURUS
LEPUS
ARIES
PISCES
ERIDANUS
Mira
CETUS
FORNAX

The Star Dome shows how the sky looks at:

9:15 p.m. local time on Dec. 1
8:15 p.m. local time on Dec. 15
7:15 p.m. local time on Dec. 30


LYRA
Vega
M-57
VULPECULA
SAGITTA
W
Deneb
CYGNUS
M-27
DELPHINUS
LACERTA
M-15
EQUULEUS
Enif
DA
PEGASUS
AQUARIUS
PISCES
Fomalhaut
SCULPTOR
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

december sky almanac

2nd	Uranus is in conjunction with the Sun.
4th	New Moon is at 7:26 a.m. EST; an annular eclipse of the Sun is visible in parts of Africa.
10th	The Moon is at apogee at 7:33 p.m. EST: 251,463 miles.
12th	First Quarter Moon occurs at 8:09 a.m. EST.
13th	Mercury will be at greatest eastern elongation (21°) and highest elevation in the evening sky. Look for it low in the southwest after sunset for the next week to 10 days.
14th	Jupiter is in conjunction with the Sun and moves into the morning sky. Also, peak activity for Geminid meteors comes during the predawn hours.
17th	In the morning sky, look for Venus close to Saturn. They will pass about 9′ of arc apart at 5:33 a.m. EST.
19th	Full Moon is at 9:00 p.m. EST; a penumbral lunar eclipse is visible across North America.
21st	Neptune is in conjunction with the Sun.
22nd	Today is the winter solstice, 5:30 a.m. EST. The Moon is at perigee at 1:26 p.m. EST: 226,709 miles.
26th	Last Quarter Moon occurs at 1:52 p.m. EST.
27th	Mars will pass about 4° north of Spica; both will be visible in the predawn sky. Also, Mercury is at perihelion.
29th	Saturn will be occulted by the Moon in the morning sky for viewers in the west and south of North America (see The Backyard Astronomer).
31st	Mercury passes through inferior conjunction with the Sun.

this month, but it will only be about magnitude 6.6, because it is at aphelion. **Pallas**, also at aphelion, is even worse off. But **Juno**, now at its closest point to the Sun, remains at seventh magnitude — rather good for this asteroid.

The **Geminid meteors** should be visible after moonset (about 1 to 2 a.m. local time) on the mornings of the 14th and 15th. The former date is probably nearer the maximum for North America, but it might be possible to see as many as 60 Geminids per hour on either morning in dark, clear skies.

Finally, December is also moderately good for **Mercury**. It is the only planet visible in the evening sky this month, reaching a greatest elongation of 20.6° on the 13th. You might spot Mercury near the young Moon on the 5th. On the last day of 1983, Mercury comes to inferior conjunction. Then all of the planets will be in the morning sky — in fact, all within a 75° span of the ecliptic.

the starry sky

By the middle of a December evening **Altair** has set and both **Vega** and **Fomalhaut** are ready to sink below the horizon. If you do not have an unobstructed view to the north, you cannot see the **Big Dipper** now low on the horizon. But if you have an unobstructed view of the northwest, you *can* see **Cygnus** the Swan standing upright as the **Northern Cross** on the horizon. Across most of the sky at this time, there is a remarkable sight: a huge region of brilliant late fall and winter constellations shining within the surrounding empty skies.

As the Star Dome shows, this bright region at first looks like a peninsula of bright stars that broadens as you follow it down to the eastern horizon — the dim stretch from Camelopardalis to Cancer helps make the bright region stand out. The promontory point of this peninsula is, perhaps, Cassiopeia high in the north, beyond which lies a rather dim region before you reach the setting Cygnus. Notice that this peninsula seems basically aligned along the Milky Way. (I'll discuss the reason next month.) But let us now begin our tour of this headland of brilliance.

We examined **Cassiopeia** last month, but keep in mind that the bright stars composing the zigzag of its main pattern are not entirely fixed in order of brightness. Keep a special watch on the middle star of the "M" pattern, **Gamma** (γ) **Cassiopeiae**. This star has been known to flare up, becoming much brighter.

Next, we move on to **Perseus**. Along with the variable **Algol**, and the **Double Cluster**, Perseus contains second-magnitude **Mirfak** (α) and a fine clustering of stars nearby (best seen in dark skies or with binoculars).

A bright Geminid meteor slices through the sky in Coma Berenices. Near the trail lies one of the open star clusters that pepper our Galaxy. About 250 light-years off, the Coma cluster is one of the closest to Earth. Michael Searle made this portrait with a 50 mm lens opened to f/2.8 and 400-speed film.

Just off one of the branching legs of Perseus is a beautiful grouping of stars near the peninsula — the **Pleiades**. In most places even urban illumination has not wiped out this wonderful cluster, whose brightest member is third-magnitude **Alcyone**.

These were the Seven Sisters, named from Greek mythology. Actually, nine stars of the cluster have names, since two are used to represent the parents of the maidens. The parents are the difficult naked-eye pair, Atlas and Pleione, which form the handle of the tiny dipper shape of the naked-eye Pleiads. The other stars — Alcyone's six sisters — are **Merope**, **Electra**, **Celaeno**, **Taygeta**, **Asterope**, and **Maia**. A few of these are difficult to spot with the naked eye unless you have dark skies and concentrate hard. Depending on the conditions, you may see anywhere from about six to nine Pleiads. Twelve is not impossible and eighteen may be the record for unaided eyes.

Eastward from Perseus is the pentagon shape of a prime winter constellation: **Auriga** the Charioteer. Its bright star, yellow first-magnitude **Capella**, is accompanied by three stars of moderate brightness called the **Kids** — baby goats, because Capella means "little she-goat" and is supposed to represent the mother goat being held with her kids by the charioteer. This is an important month to observe the Kids because it should be the last month that the one nearest Cappella, **Epsilon** (ε) **Aurigae** (sometimes called Ma'az) is in the deep part of its thrice-a-century eclipse. Compare its brightness this month with the other Kids, and then perform this observation in each of the winter and spring months. Astronomers are currently trying to unravel the mystery of this strange star.

The star **Beta** (β) **Tauri** (El Nath) attaches Auriga to noble **Taurus** the Bull. The Pleiades are off in the shoulder of the Bull, but his main pattern is formed by lines drawn from his horn-points (Beta and **Zeta** [ζ] **Tauri**) southwest to a V of stars. One star in this V is the first-magnitude lucida (brightest star) of Taurus, **Aldebaran** (the name means "the follower" — probably referring to the fact that Aldebaran follows the Pleiades as they rise). The other stars of the V are much more distant than Aldebaran and together form the Hyades star cluster, very important in astronomers' measurements of stellar distances. They form a fine view that fills the field of binoculars, including some attractive wide doubles (a few of these doubles can be split with good unaided vision).

Perseus, Auriga, and Taurus are undoubtedly among the most striking constellations in all the heavens — but if anything, our host of stars now gets even better as we look lower in the east and northeast on December evenings. We see **Gemini** the Twins with the stars Castor and Pollux. We see **Orion** the Hunter, most splendid constellation of all, with his three-star Belt and his bright giants, Rigel and Betelgeuse. And finally we see the two Dog Stars, now rising high enough for a good view as Vega and Fomalhaut set. The fainter star is **Procyon**, while the brighter is the most radiant star in all the heavens, the magnitude −1.5 blue-white jewel called **Sirius**. After Sirius and Procyon ascend well into the sky, there is no more stellar magnificence to come for awhile — our peninsula really is a great island in the sea of dark sky.

skylore

This month and next, we are going to take a two-part look at the lore surrounding one of the most ancient of constellations, Taurus the Bull. The second part will deal with such matters as Taurus' connection with the possible origin of unicorns, the way Orion faces, and the alphabet itself. This month, however, let us concentrate on the Greek myth with which Taurus is usually associated.

Perhaps the most famous of Zeus' relations with earthly maidens was his affair with Europa. The young woman is usually said to be the daughter of Telephassa and Agenor, the king of a land that later became Phoenicia. Europa went out one morning with other maidens to gather flowers in their favorite meadow by the sea. She caught sight of a mighty but beautiful form — a bull like none other that she had ever seen.

Some say that his color was snow-white, others chestnut; all agree that his coat glistened with beauty in the sun. His horns were as shapely as the crescent Moon, and though he looked powerful, his demeanor seemed so gentle that Europa and the other maidens drew nearer to admire the creature. Europa thought to herself that the bull seemed more like a man than an animal. When he lay down at her feet, it seemed like an invitation to mount him and she accepted that invitation.

The mighty bull leaped to his feet and sprang away to the sea. Her terror blended with amazement when she opened her eyes and saw that his heavy galloping hooves were borne lightly upon the tops of the waves. All around her, sea-gods on dolphins (even Poseidon himself) sprang up and accompanied the pair.

She was, of course, carried off by the king of the gods, Zeus, in the guise of a bull. After a 600-mile journey across the wave tops, Zeus ravished Europa in Crete, his birth-land. Unlike some of Zeus' less fortunate conquests, however, Europa did not suffer the revenge of Hera, Zeus' wife. She eventually bore Zeus three sons. Two were Minos and Rhadamanthys, who ruled Crete after their foster father (Europa's eventual husband), Asterius. After their own deaths, they became two of the three noble judges in the underworld (the third was Aeacus). The last son of Europa was Sarpedon, who became an ally of Priam in the Trojan War and was killed by Achilles' friend Patroclus.

Europa had five brothers, all of whom went in search of her. They never found her, but they did find adventures. The most famous episode is the story of Cadmus, who founded Thebes with the help of men he sowed from dragon's teeth.

The constellation Taurus has usually been identified with the disguise Zeus assumed to carry Europa away. You may also be well aware that Europa's name has been given to a major moon of Jupiter (Roman version of Zeus) — and to the continent we now call Europe. But all these Greek associations with the constellation Taurus are later developments in the thousands of years of lore about this important zodiacal figure. Next month we will look at some other remarkable aspects of Taurian legend.

The Bowl of Night

A HAND-
CRAFTED THREE
DIMENSIONAL
PLANISPHERE FOR
VIEWING THE
NIGHT SKY

The BOWL OF NIGHT™ is a desk top planisphere that solves the ancient problem of accurately representing the night sky. The vault of the heavens is more obvious than on any flat sky map. Skywatching is fun when you can understand how celestial objects move. By turning the opaque horizon hemisphere inside the blue bowl of stars, you can display the night sky for any hour of the night, any time of year. The BOWL OF NIGHT™ comes with an instruction pamphlet and is 14½" in diameter, made by SPHERICAL CONCEPTS, INC., the exclusive licensed manufacturer of the original BOWL OF NIGHT.™ *Patent pending.

Another Hand-crafted Creation of **Spherical Concepts, Incorporated** 941 Parkview Drive King of Prussia, PA 19406 Telephone: 215:783-0272 Makers of **Spheres of Influence®**

To: **Spherical Concepts, Inc.**
941 Parkview Drive
King of Prussia, PA 19406

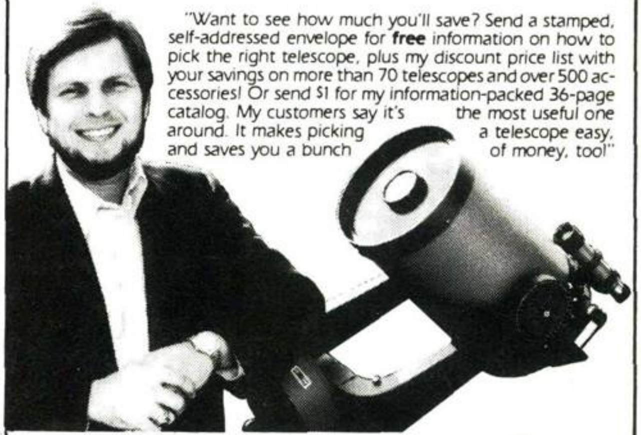
Bowl of Night™
— $65.00 ea.

Please send me ______ BOWL(s) OF NIGHT™ with instruction pamphlet(s). If I am not completely satisfied I may return my BOWL(s) OF NIGHT™ within thirty (30) days and receive a complete refund. Enclosed you will find my check for ________ plus three dollars ($3.00) for shipping and handling or bill by VISA/MASTERCHARGE card.

VISA/MASTERCHARGE
Card # ______________________ exp. date __________
Name ______________________________
Address ______________________________
City ______________ State ________ Zip ______________

We have 97 telescopes in stock, 324 eyepieces, 50 Barlows, literally hundreds of other accessories — and all priced to save you money!

Celestron, Meade, Questar, Coulter, Edmund, Bushnell Criterion, TeleVue, Lumicon, Unitron, Accutrack, Brandon, DayStar, University Optics
— we'll save you money on all of them!



"Want to see how much you'll save? Send a stamped, self-addressed envelope for **free** information on how to pick the right telescope, plus my discount price list with your savings on more than 70 telescopes and over 500 accessories! Or send $1 for my information-packed 36-page catalog. My customers say it's the most useful one around. It makes picking a telescope easy, and saves you a bunch of money, too!"

Ad•Libs Astronomics

2401 Tee Circle, Suite 106, Norman OK 73069

MasterCard, Visa
North American sales only.

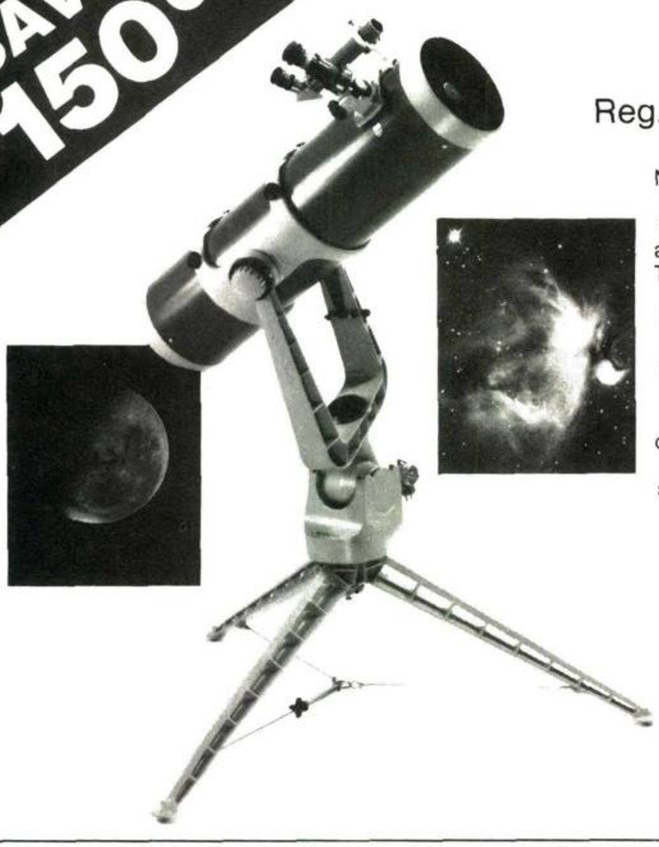
(405) 364-0858

Now in our 5th year
of saving you money!

SAVE
$150⁰⁰

Edmund Scientific 8-Inch f/5 Telescope System

Reg. $899.00 NOW ONLY **$749.00**



Now the excellence you've come to expect from Edmund Scientific costs less. You already know our 8-Inch f/5 Telescope is an exceptional deep sky instrument. At a savings of $150, it's even a greater astronomical value! This scope offers a three point adjustable primary mirror cell & a fully adjustable secondary mirror cell with patented 0.005 in. supporting vanes to maintain optical alignment. It offers views from rich field to diffraction limited high resolution. The Newtonian system minimizes aberrations common to compound optics systems without sacrificing the superb light-gathering ability. Sturdy construction allows the Edmund 8-Inch f/5 to "damp out" faster than other telescopes. Comes complete with setting circles on both axes, fine adjustment declination control, a hysteresis synchronous motor drive, a 2 in. focuser and an impact resistant ABS plastic tube. The lightweight Equatorial Fork Mount delivers remarkable stability, uncommon portability and easy access to any part of the sky. To order your 8-Inch f/5 Telescope, call **Toll Free 1-800-257-6173.** In New Jersey, dial 1-800-232-6677. For additional information on the 8-Inch f/5 Telescope, ask for Bill Shonleber.

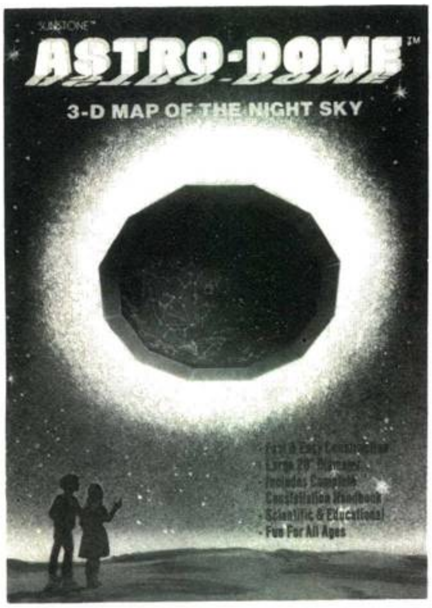
Edmund Scientific Co.
101 E. Gloucester Pike, Dept. T206
Barrington, N.J. 08007

ASTRO-DOME™

NEW!

3-D MAP OF THE NIGHT SKY

- Fun for All Ages
- Stars Glow in the Dark
- Scientific and Educational
- Includes 24 page Constellation Handbook


SUNSTONE™
ASTRO-DOME™
3-D MAP OF THE NIGHT SKY
Fun & Easy Construction
Large 20" Diameter
Includes Complete Constellation Handbook
Scientific & Educational
Fun For All Ages

CREATE A MINI-PLANETARIUM FOR YOUR HOME

For thousands of years, people have looked up and been awed by the beauty and mystery of the night-time sky. Now you can create a miniature planetarium for your own home using the new book, Astro-Dome.™

Upon completion of the easy-to-follow instructions, the pre-cut pages of this book are transformed into an attractive three-dimensional dome. The inside of the dome shows the stars and constellations as seen from the Northern Hemisphere. It measures 20" in diameter and the stars are specially printed so they "glow in the dark" for more realistic viewing. Included with the dome is a 24 page illustrated Constellation Handbook explaining the history, myths and most prominent stars of the major constellations.

Both fun and educational, the Astro-Dome™ appeals to all ages. It makes a great gift and room decoration. This new book retails for $6.95 and is available in your local bookstore or hobby shop. For more information and the name of a dealer near you, write to Sunstone Publications, 21 Glen Avenue, P.O. Box 788AT, Cooperstown, NY 13326.

To order send $6.95 for each Astro-Dome™ to Sunstone Publications, 21 Glen Ave., P.O. Box 788AT Cooperstown, N.Y. 13326. (N.Y. residents please add sales tax.)

Please send me ________ copies of the new Astro-Dome™ book. Enclosed is ____________.

Ship to:
Name ______________________________
Address ______________________________
City ______________________________
State ______________________ Zip________

ASTRONOMY Bookshelf

GALAXIES: Ferris. Magnificent visual tour of the cosmos — from our own Milky Way to dozens of other galaxies through stunning images (many in color) from the world's largest telescopes. 192 pages.

Hardcover — **$27.50**
Paperback — **$17.50**

THE VOYAGER FLIGHTS TO JUPITER AND SATURN: Jet Propulsion Laboratory. Compiled as a glorious photo-album of the Voyager encounters — combines a history of the missions with a portfolio of color photographs from the flybys. 61 pages, paperback.

$6.95

ASTRONOMY: SELECTED READINGS: ed. Seeds. A gloriously colorful anthology of 11 of the best articles run in ASTRONOMY. Covers the whole range of astronomical research. 178 pages, paperback.

$13.50

VOYAGES TO SATURN: Morrison. The exciting story of the two Voyager encounters with Saturn. Follow the encounters day-by-day and peek over the scientists' shoulders to discover what they learn about Saturn. Profusely illustrated in color. 277 pages, paperback.

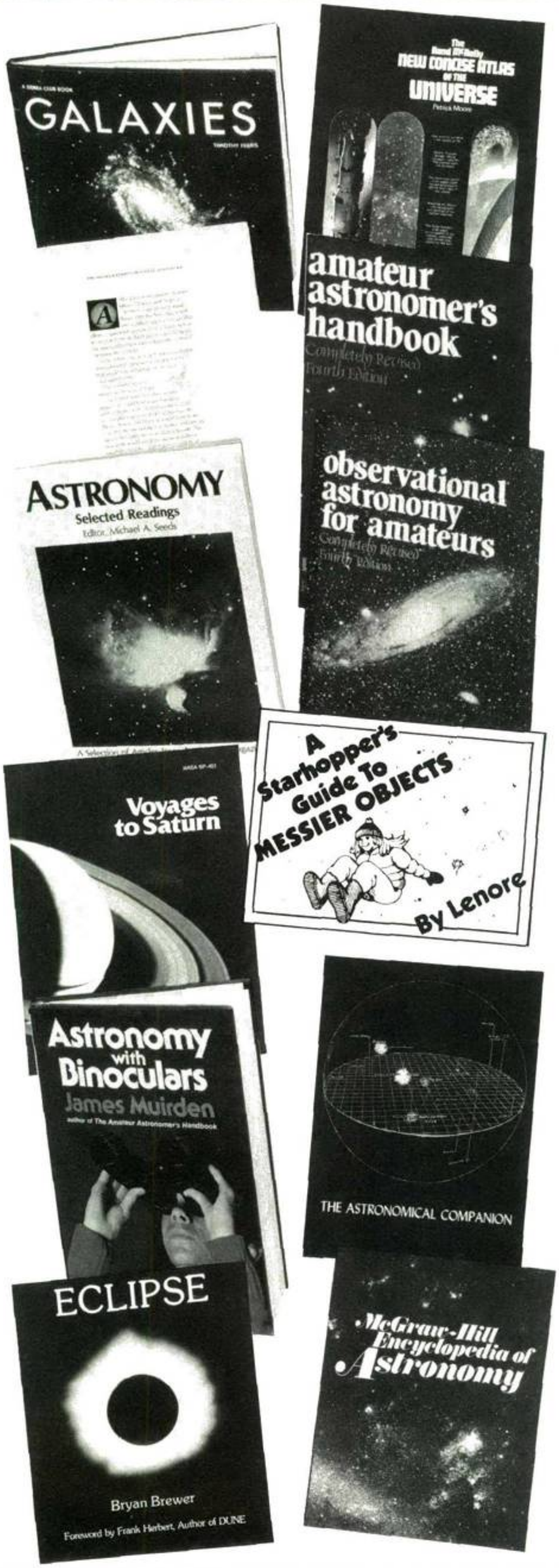
$11.95

ASTRONOMY WITH BINOCULARS: Muirden. The classic guide to sky-watching with the simplest equipment. Includes how to buy a good pair of binoculars and observing projects. 156 pages, hardcover.

$13.95

ECLIPSE: Brewer. The exciting story — beginning with remotest antiquity and continuing up to the present — of humankind's perpetual fascination with the most fleeting and beautiful of all spectacles in nature: a total eclipse of the Sun. 102 pages, paperback.

$6.50


GALAXIES
The Rand McNally New Concise Atlas of the Universe
amateur astronomer's handbook
Completely Revised Fourth Edition
ASTRONOMY
Selected Readings
observational astronomy for amateurs
Completely Revised Fourth Edition
A Starhopper's Guide To Messier Objects
By Lenore
Voyages to Saturn
Astronomy with Binoculars
James Muirden
THE ASTRONOMICAL COMPANION
ECLIPSE
Bryan Brewer
Foreword by Frank Herbert, Author of DUNE
McGraw-Hill Encyclopedia of Astronomy

RAND McNALLY'S NEW CONCISE ATLAS OF THE UNIVERSE: Moore. Large-format guide to the sky with almost 1000 photos, 400 in full color. 190 pages, hardcover.

$36.50

AMATEUR ASTRONOMER'S HANDBOOK, 4th ed.: Sidgwick. Tips on mountings and drives, eyepieces, mirror and lens testing — as well as data on human vision, the Earth's atmosphere, etc. 568 pages, paperback.

$8.50

OBSERVATIONAL ASTRONOMY FOR AMATEURS, 4th ed.: Sidgwick. A collection of facts on observing techniques covering the Sun, Moon and all the planets, as well as aurorae, meteors, zodiacal light and double stars. 348 pages, paperback.

$6.50

A STARHOPPER'S GUIDE TO MESSIER OBJECTS: Freeman. Taking only the naked-eye stars of each constellation, *A Starhopper's Guide* shows you how to locate each of the 110 Messier objects by "hopping" to them from easy-to-find bright stars. The method is simple and direct — you can't get lost! 23 pages, paperback.

$7.50

ASTRONOMICAL COMPANION: Ottewell. Large-format book that shows how the Earth relates to other planets, comets, nearby stars and neighboring galaxies. Provides superb visual perspectives with 300 large drawings and numerous smaller ones. 73 pages, paperback.

$12.50

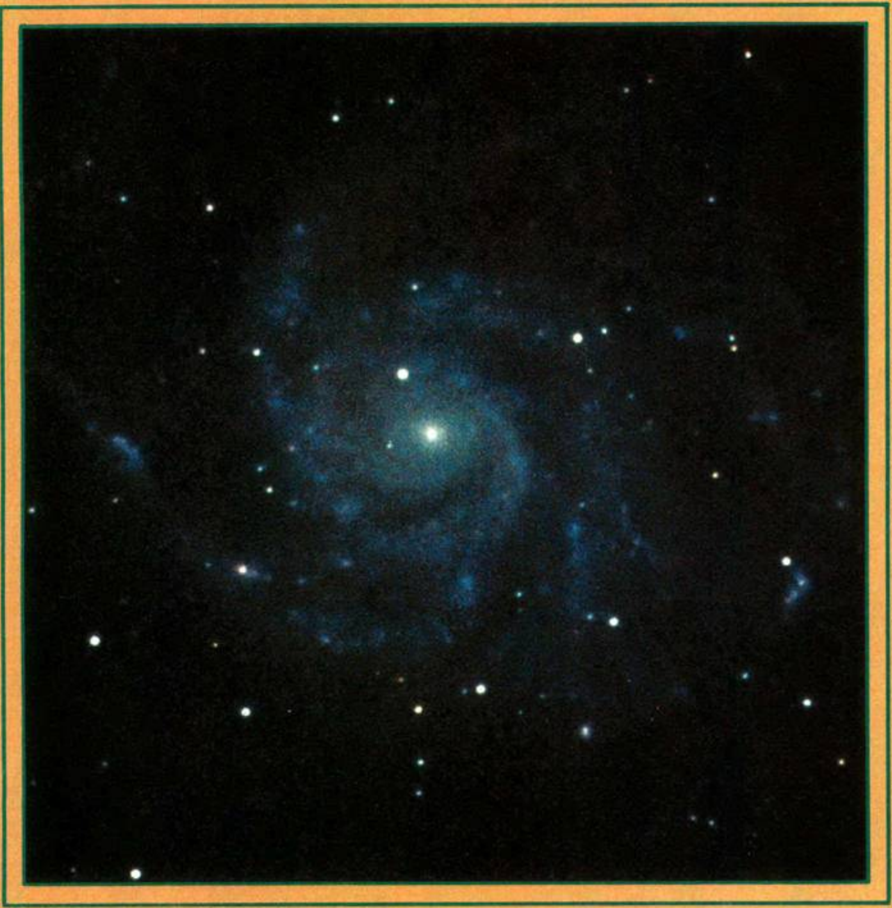
MCGRAW-HILL ENCYCLOPEDIA OF ASTRONOMY. Provides authoritative and up-to-date coverage of the broad and active field of modern astronomy. Very comprehensive and written in a layperson's terms. 450 pages, hardcover.

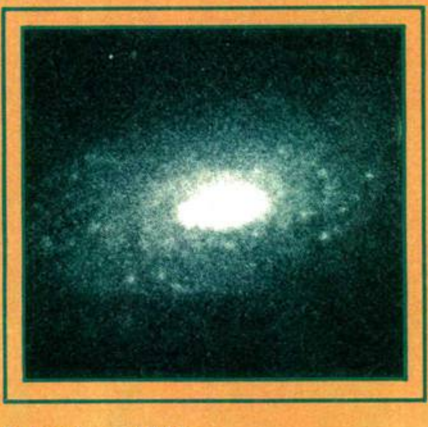
$45.95

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

photographing detail in galaxies

photography in astronomy





Above: Using his 14-inch SCT with an f/5.5 telecompressor, Bill Iburg photographed the soft, knotty arms of M-101 in Ursa Major. The 45-minute exposure — made with a cold camera on 400 ASA slide film — shows dark rifts in the arms, several HII regions, and the tiny condensed nucleus. Left: Martin Germano photographed the subtle mottled spiral arms and oval core of galaxy M-63 with his 8-inch f/10 SCT. He used 103a-F emulsion and a 60-minute exposure.

It wasn't long ago that the very best amateur photos of galaxies showed them as little more than fuzzy blobs. But during the last 20 years fast Newtonians, Schmidt cameras, and telecompressors — coupled with cooled emulsion and hypersensitization techniques — have led to a new "high tech" level of photography. Amateur astronomers now make portraits of deep-sky objects that rival the work of major observatories a number of years ago. This new capacity offers exciting possibilities to budding astrophotographers.

Shooting the Galaxies

Your success in capturing structure in distant galaxies will depend on your equipment and mastery of astrophotographic technique. Almost any telescope equipped with an equatorial mount and tracking drive is capable of producing a long-exposure astrophoto. A good "fast" Newtonian — usually in the f/5 to f/7 range — works well for photographing galaxies. Schmidt-Cassegrains are photographically pretty slow (f/10 or greater); if you use one, you may want to get a telecompressing lens, resulting in an f/5 to f/8 system. Although amateurs successfully do deep-sky photography at focal ratios of f/10 or more, it is not an easy way to start. Schmidt cameras or large telephoto lenses work well for large galaxies, especially when used with fine-grain film.

If you're just getting started in astronomical picture making, the following ASTRONOMY articles will help you get geared up for through-the-telescope photography: "Capture a Galaxy on Film," April 1978; "Exposure in Astrophotography," August 1978; "Guiding," December 1980; "Making the Most of Black and White Astronegatives," January 1982; "Getting the Most from Slide Films," January 1983; "Off-Axis Guiding: Pain or Panacea?" February 1983.

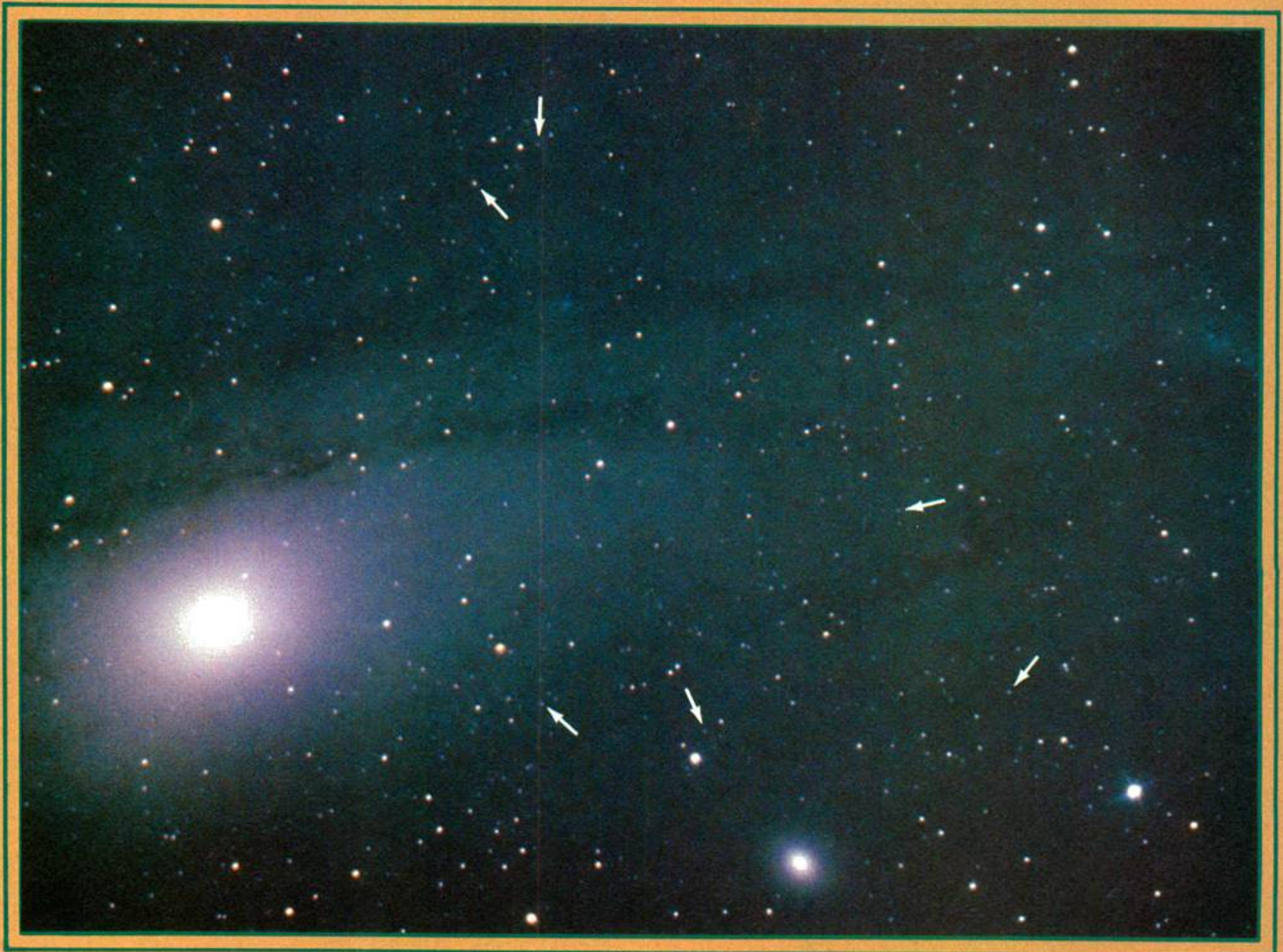
Which Films Are Best?

Most photographers use black and white film because it is easy to work with and records detail better than color emulsions. If you have a darkroom, or access to one, you will be able to control the quality of your negatives (see "Developing Black and White Astrofilms," September 1976, and "A Darkroom for Astrophotography," September 1980). Without a darkroom, you'll be sending your highly prized work off to processors accustomed to churning out pictures of people, and you may well be sorry when you get them back. Color films work well, but need longer exposures and trickier developing than the black and whites.

For years pioneering celestial photographers used Tri-X, but this was supplanted by the 103a spectroscopic films; they dramatically improved results due to their high sensitivity and low reciprocity failure. They are still the standard deep-sky films. Because of its blue sensitivity, 103a-O is a good choice for photographing spirals. Nuclear regions and elliptical galaxies show up best on red-sensitive 103a-F or 103a-E. These films record faint light quickly, but suffer from a fair amount of grain. The recent widespread use of film hypersensitization opened up Technical Pan 2415 as a top-notch film: When "hypered" in a mixture of 92% nitrogen and 8% hydrogen it performs superbly, eliminating the grain problem almost entirely, yet offers reasonable speed. (See "Cold Camera vs. Gas Hypering," November 1981, and "The 2415 Revolution," March 1982.)

What Can You Photograph?

Galaxies vary as much in size, shape, and appearance as do people. Spiral galaxies are not only the most attractive, but offer perhaps the greatest variety of visible phenomena. They are great pinwheel collections of gas, dust, and billions of stars. Features we observe "back home" in the Milky Way are also present in other galaxies: star clouds, HII emission regions, stellar associations, globular clusters, and novae (and possibly supernovae), many of which show up in well-made photos taken with backyard equipment. We can also record galactic nuclei of different types and dramatic dust lanes. Barred spiral galaxies offer many of the same features. Elliptical galaxies present a generally featureless and bland appearance because they are spheroid and lack interstellar gas and dust. They are, however, accompanied by large halos of globular clusters. Lenticular (lens-shaped) galaxies do not have spiral arms and are more or less a transition between the spirals and ellipticals. Irregular and peculiar galaxies appear as strange distorted shapes with many features due to their bizarre nature, and they include,



Above: Jack Newton's shot of M-31's nuclear region shows the condensed nucleus, faint spiral arms, dark lanes, the star cloud NGC-206, and several globular clusters (indicated). He took this photo with a 16-inch f/5 Newtonian, 400 ASA film, and a 14-minute exposure. Top Right: Martin Germano used an 8-inch f/10 SCT, 103a-F film, and a 60-minute exposure to capture M-95's tiny nucleus, central bar, and faint arms. Center Right: An identical exposure by Germano recorded the stellar nucleus, face-on knotty arms, and central bar displayed by galaxy M-61 in Virgo. Bottom Right: Another Germano shot with the same setup and exposure reveals the bizarre nature of colliding galaxies NGC-4038 and NGC-4039 in Corvus. Far Right: To record the condensed nucleus, spiral arms, large gas clouds, and dust patches of M-81, David Healy employed a 14-inch SCT, f/5.5 telecompressor, hypersensitized 2415 film, and a 40-minute exposure.

exploding, colliding, and otherwise distorted galaxies.

Since visible detail falls off with greater distances, the nearer galaxies offer the best chance to get started in recording galactic detail. The brightest galaxy in the sky, M-31 in Andromeda, is our "sister" spiral in the Local Group; at a distance of 2.2 million light-years, it offers plenty to patient cameras. Short exposures reveal a tiny condensed nucleus with only a faint haze surrounding it; exposures of 15 to 30 minutes, however, record a bright egg-shaped nucleus, wavy intricate dark lane structure, the large spiral arms, M-31's two nearby satellite galaxies, the star cloud NGC-206, and a number of tiny globular clusters. The low surface brightness galaxy M-33, 2.3 million light-years away in the direction of Triangulum, reveals an impressive amount of detail: The galaxy's distinct but tenuous spiral arms break up

selected galactic detail

NGC	M	R.A. (2000)	Dec.	Mag.	Recordable Detail
224	31	00h 43m	+41°08′	4.5	SA, DL, CN, SC, GC, SG
253		00h 48m	−25°18′	7.0	SA, SN, DL
520		01h 25m	+03°48′	12.4	DL, P
598	33	01h 34m	+30°40′	6.5	SA, SN, EN, SS, GC, DL
628	74	01h 37m	+15°48′	11.0	SA, CN, DL
891		02h 23m	+42°21′	12.2	DL
1068	77	02h 43m	−00°02′	10.0	SN
1300		03h 20m	−19°24′	11.3	SN, SA, BR
2403		07h 37m	+65°37′	8.9	SA, EN, DL
2903		09h 32m	+21°29′	9.7	BR, SA, DL, CN
3031	81	09h 55m	+69°04′	8.5	SA, CN, DL, GD
3034	82	09h 56m	+69°41′	9.2	DL, P
3351	95	10h 44m	+11°42′	11.0	BR, CN
3556	108	11h 12m	+55°41′	10.8	DL
4038/9		12h 02m	−18°51′	11.0	P
4258	106	12h 19m	+47°19′	9.0	SA, CN
4303	61	12h 21m	+04°37′	10.2	SA, CN
4565		12h 35m	+26°06′	10.5	DL, SN
4594	104	12h 39m	−11°18′	8.2	DL
4826	64	12h 57m	−21°41′	8.6	DL, CN
5055	63	13h 16m	+42°02′	9.8	SA, GD, CN
5194	51	13h 30m	+47°11′	8.7	SA, SG, CN, DL, SC
5457	101	14h 03m	+54°22′	9.0	SA, SC, DL, SN
6946		20h 35m	+60°09′	11.1	SA, DL, SN

Detail code: SA = spiral arms, DL = dust lane or patches, CN = condensed nucleus, SC = star clouds, GC = globular clusters, SG = satellite galaxies, P = peculiar features, BR = barred structure, SN = stellar nucleus, EN = emission nebulae, SS = stellar associations.

in large stellar associations, and it shows a tiny stellar nucleus, several large HII regions, and even a few globulars.

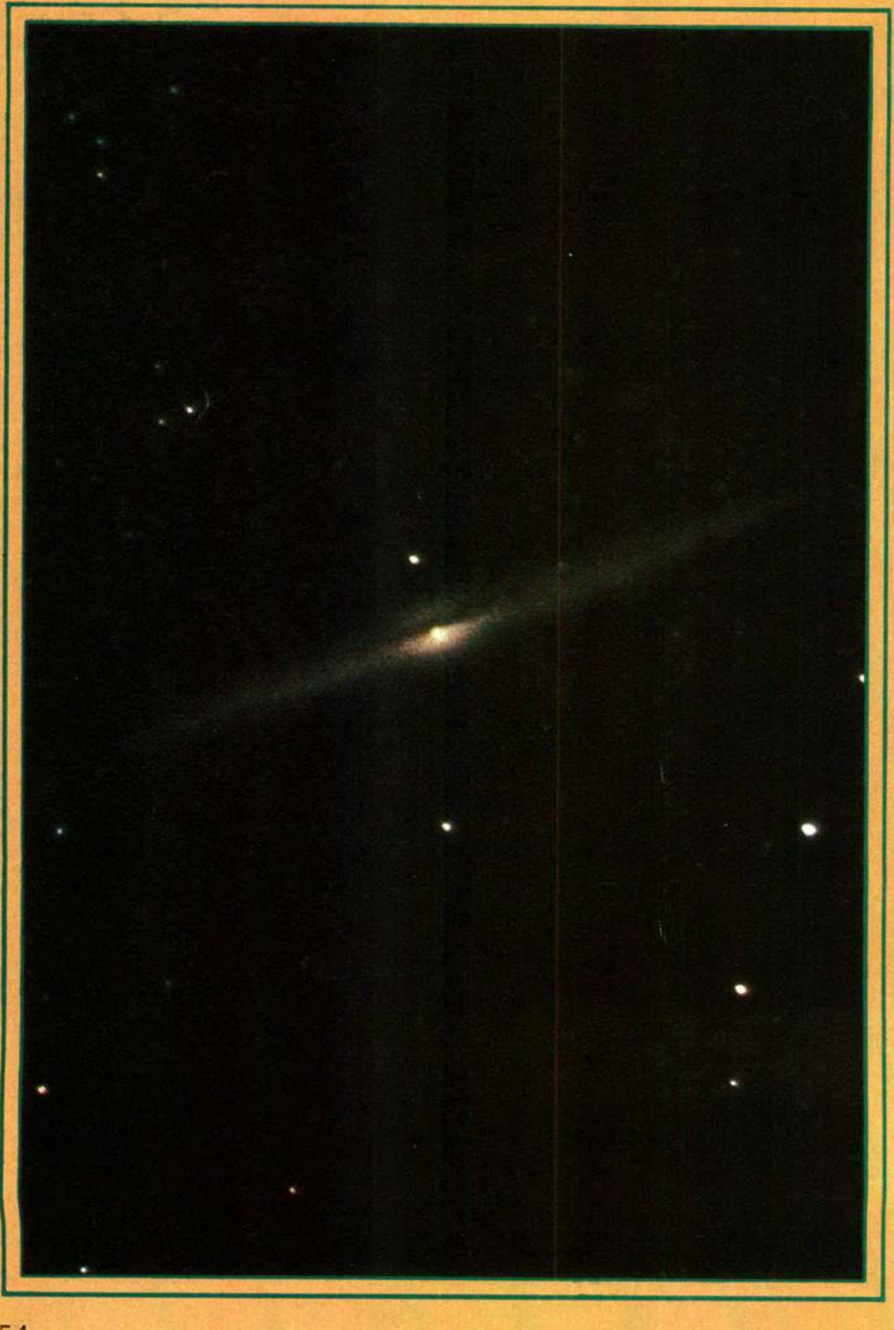
Going for detail in more distant targets becomes progressively more challenging. M-81, a bright spiral in Ursa Major, lies seven million light-years distant and shows highly inclined spiral arms extending far out from a very bright nucleus, subtle knots in the arms, and dust patches near the nucleus. In the same constellation and twice as distant, the low surface brightness spiral M-101 shows up in long exposures as a circular patch with a tiny nucleus and long arcing spiral arms, broken up into many knots of gaseous material. At the same distance as M-101 is the giant elliptical galaxy NGC-5128, easily showing a broad dark lane with bright loops of nebulosity even in five-minute exposures. A deeper photograph shows that this object is highly distorted, justifying its classification as "peculiar."

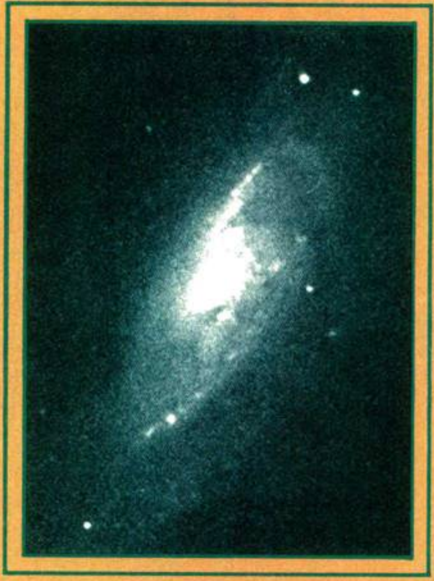
Lying at a distance of 20 million light-years is the sky's finest edge-on galaxy, NGC-4565 in Coma Berenices. Short exposures portray this object as a faint silvery needle of light; 30-minute shots reveal a tiny stellar nucleus, a noticeable central bulge, and a thick dust band running through the galaxy. Farther out at 30 million light-years' distance, M-95 in Leo shows a faint luminous ring of matter around its barred spiral structure and bright nucleus. Going upward of 100 million light-years pushes amateur equipment to its absolute limits: The remote colliding galaxy pair NGC-4037 and NGC-4038 looks like a strange knotty little arc after a one-hour exposure, careful darkroom work, and extreme enlargement. At great extragalactic distances, you must be satisified with simply recording the object and foregoing any detail within it. You can photograph 3C-273, a quasar in Virgo some three billion light-years away, but it appears as only a star.

Getting There Is Half the Fun

The first few times you sneak out into the night, guide your softly whirring telescope for 10 minutes, sneak back in the house and develop the film, don't be too hurt if the end result is an ugly, fogged-black strip of film. Getting a decent photograph of a galaxy is a difficult operation. It takes time and, most important, a great deal of practice. Keep at it, and pretty soon you'll be shooting spiral arms, galactic nuclei, dust lanes, and HII regions with the best of 'em. And when that happens you'll be hooked on one of the most satisfying aspects of backyard astronomy: capturing a distant part of the universe and storing it away for a cloudy night.

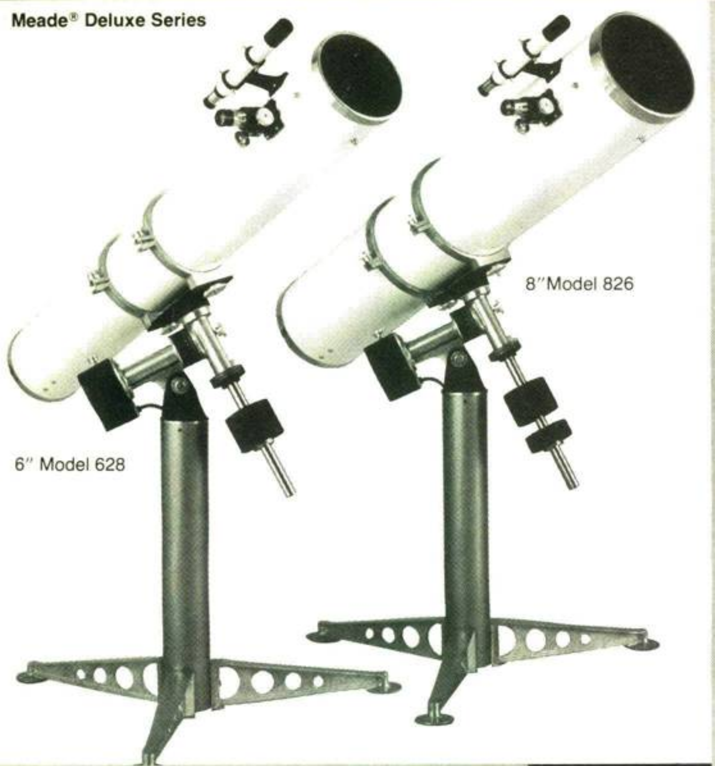
— *David J. Eicher.*





Left: Bill Iburg recorded the tiny nucleus, central bulge, and broad dust lane of edge-on galaxy NGC-4565 with his 14-inch SCT, f/5.5 telecompressor, 400 ASA slide film chilled by a cold camera, and a 45-minute exposure. Above: Using an 8-inch f/10 SCT coupled with 103a-F film and a 70-minute exposure, Martin Germano captured M-106 with its elongated nucleus, sharp spiral arms, and dusty disk.

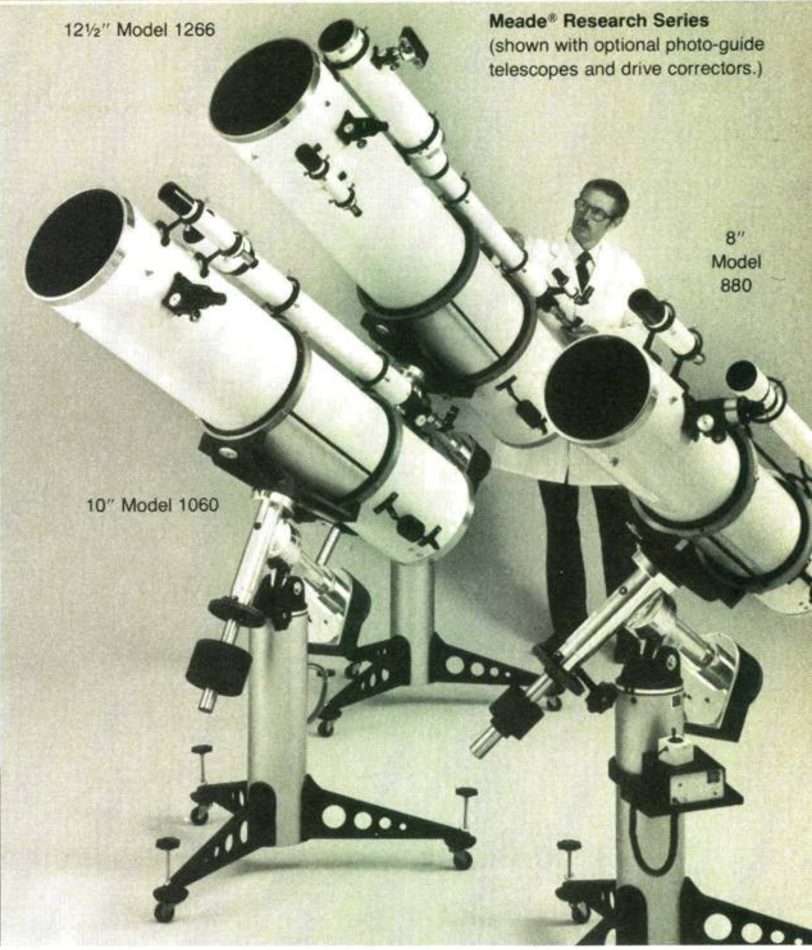
Meade® 6″, 8″, 10″, 12½″ Newtonian Reflecting Telescopes



Meade® Deluxe Series

6″ Model 628

8″Model 826

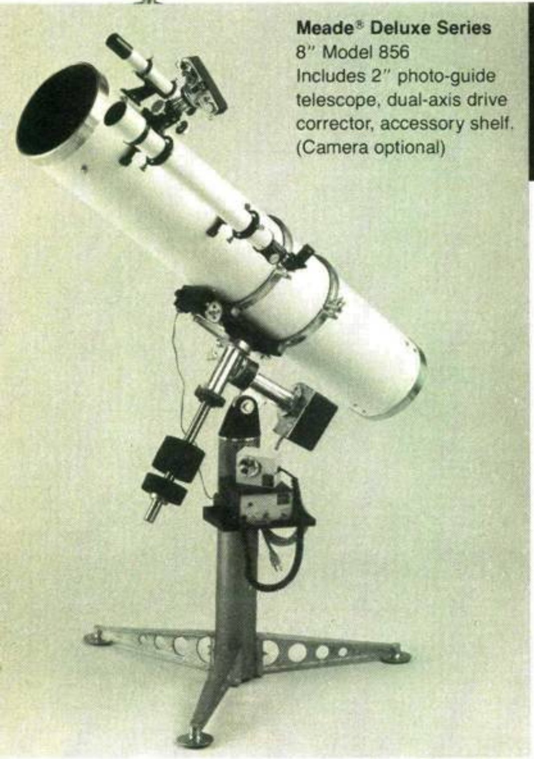


12½″ Model 1266

Meade® Research Series
(shown with optional photo-guide telescopes and drive correctors.)

8″ Model 880

10″ Model 1060



Meade® Deluxe Series
8″ Model 856
Includes 2″ photo-guide telescope, dual-axis drive corrector, accessory shelf. (Camera optional)

Meade Deluxe Series 6″ and 8″ Reflecting Telescopes

The most popular reflecting telescopes in the World for the serious amateur. Diffraction-limited 1/10-wave parabolic primary mirrors with matching elliptical flat secondaries. Mounts machined to .001″ tolerances for a lifetime of precision tracking, visually and photographically. Polar and Dec. shafts 1″ dia. solid steel. Complete with Motor Drive (115V./60Hz) and automatic clutch; setting circles; 2 Modified Achromatic eyepieces threaded for filters; 6 x 30 achromatic viewfinder; rack and pinion focuser; rotating ring system. Fiberlite tube with ultrahard white epoxy coating and metal trim rings. Excellent astrophotographic capabilities with your 35mm camera.

Meade Research Series 8″, 10″, 12½″ Reflecting Telescopes

For the advanced observer/astrophotographer, the largest-selling instruments of their kind, by far. Oversize equatorial mounts with double Sealmaster ball-bearings, 1½″ solid steel shafts, 6″ engraved setting circles, and machined Nylon-bearing tube rotation system. Diffraction-limited 1/10-wave optics. Standard accessories: giant #680 focuser for 1¼″ and 2″ O.D.; 8 x 50 viewfinder; 2 multi-coated Orthoscopic eyepieces.

PRICE LIST

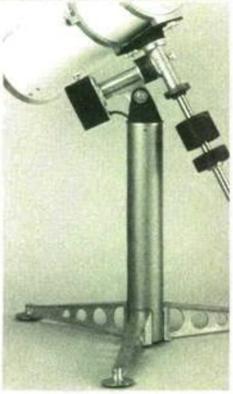
COMPLETE DELUXE SERIES TELESCOPES	
Model 628: 6″ f/8 with Motor Drive	$ 519.50
Model 645: 6″ f/5 with Motor Drive	529.50
Model 826: 8″ f/6 with Motor Drive	649.50
Model 856: 8″ f/6 with Motor Drive, 2″ Guide Telescope, Dual-Axis Drive Corrector, Accessory Shelf	979.50
COMPLETE RESEARCH SERIES TELESCOPES	
Model 880: 8″ f/6 with Motor Drive	$1575.00
Model 1060: 10″ f/6 with Motor Drive	1985.00
Model 1266: 12½″ f/6 with Motor Drive	2495.00

COMPLETE EQUATORIAL MOUNTS	
Model 652: 6″ with Motor Drive	$ 225.00
Model 852: 8″ with Motor Drive	260.00
Model 1071: 10″ with Motor Drive	1025.00
Model 1277: 12½″ with Motor Drive	1075.00

All prices **include** packing; F.O.B. Costa Mesa, Calif.

Equatorial Mounts

The exact same Equatorial Mounts used on Meade Deluxe and Research Series Telescopes are available for separate purchase. Each mount includes equatorial head with motor drive, setting circles, and saddle plate; pier; tripod legs. Tube cradle rings available optionally.

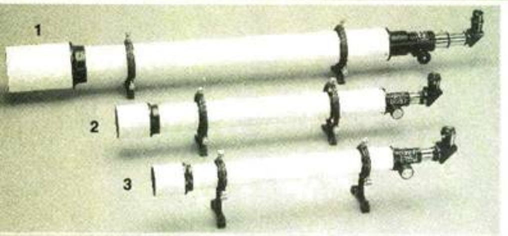


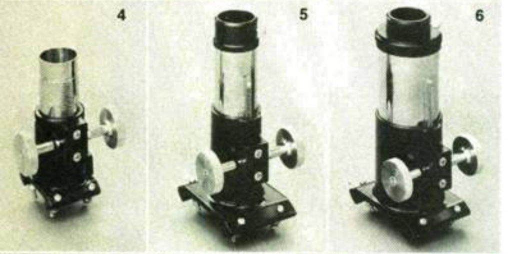
Meade Instruments Corporation

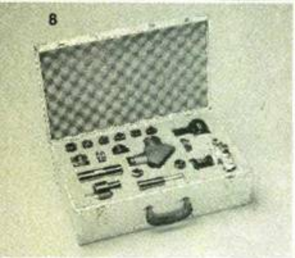
1675 Toronto Way, Costa Mesa, California 92626 ▫ **(714) 556-2291**

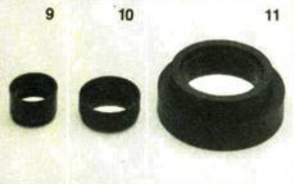
For toll-free dealer locations or factory-direct ordering assistance please turn the page. ⇨

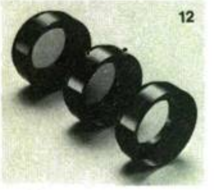
Meade® Research Quality Accessories & Parts











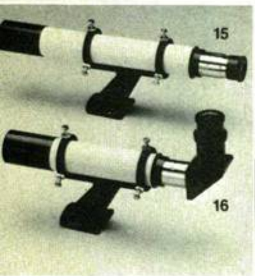


PHOTO-GUIDE TELESCOPES—Each with coated, air-spaced objective, rack-and-pinion focuser, diagonal prism, 9mm crosshair eyepiece.

1—**Model 300PG:** D=80mm (3.1"); F=1200mm (f/15) ... **$215.00 ppd.**
2—**Model 280PG:** D=60mm (2.4"); F=700mm (f/11.7) ... **$89.50 ppd.**
3—**Model 210PG:** D=50mm (2.0"); F=600mm (f/12) ...... **$69.50 ppd.**
Mounting Rings: for #210PG .... per pr. **$12.50 ppd.**
for #280PG, #300PG .... per pr. **$14.50 ppd.**

RACK-AND-PINION FOCUSERS—All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders.

4—**Model 67**—Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. .... **$24.95 ppd.**
5—**Model 640** — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. .... **$39.95 ppd.**
6—**Model 680**—Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 18" telescopes. .... **$49.95 ppd.**

ACCESSORY CASES—For secure storage of eyepieces, Barlows, filters.

7—**Model 54:** Thick-wall polyethylene with latch and handle. Holds 7 eyepieces & Barlow, filters. Dims. 12" x 8" x 3¾" ...... **$14.50 ppd.**
8—**Model 50:** Luggage-quality metal case with 2 latches, handle; foam custom fits to your accessories. Dims. 20" x 12" x 6½" **$49.50 ppd.**

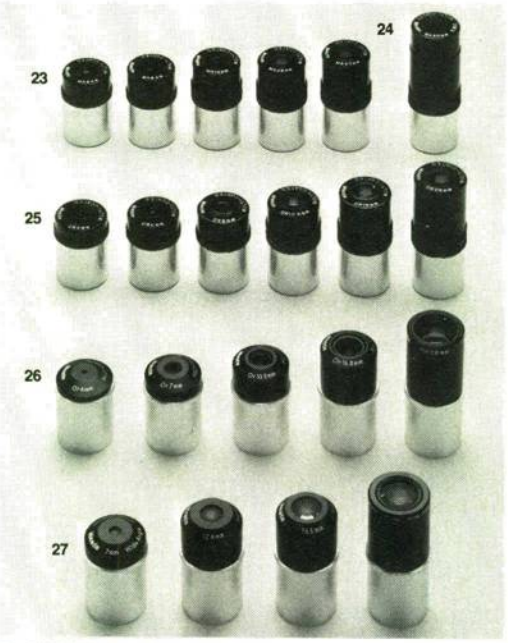
NEBULAR FILTERS—Revolutionary 3-channel filters block natural airglow & sodium and mercury emissions from city lights. Dramatically improve telescope performance visually and photographically.

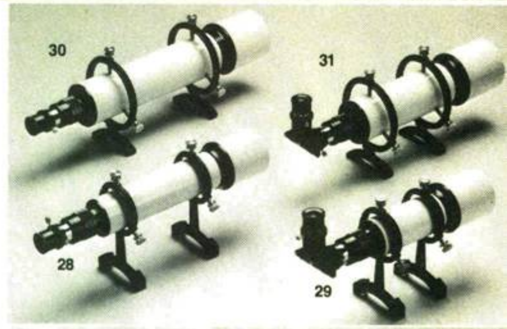
9— **Model 907:** 18mm aperture, for .965" O.D. eyepieces .. **$49.95 ppd.**
10—**Model 908:** 23mm aperture, for 1¼" O.D. eyepieces .. **$55.00 ppd.**
11—**Model 911:** 36mm aperture, threads directly onto rear-cell of Meade and other brands of Schmidt-Cassegrains. .... **$79.50 ppd.**

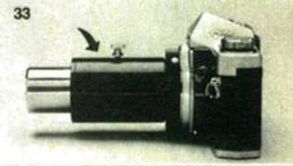
12—**PHOTO-VISUAL COLOR FILTERS**—Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Thread directly into 1¼" O.D. barrels. Filters may be piggybacked. **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each **$8.95 ppd.**

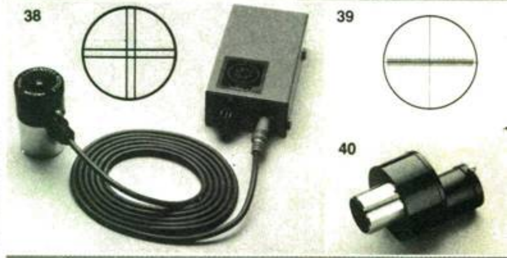
13—**VARIPAK DRIVE CORRECTOR—Model 43:** Supercompact 2" x 3" x 4" design. Fast-slow pushbuttons. Variable speed control. Operates from 12 volts D.C., plugs into standard auto cigarette lighter The 12-watt output is sufficient for most telescopes to 14" aperture .... **$69.50 ppd.**

17
18
19
20
21
22









14—**VARIGUIDE DRIVE CORRECTOR — Model 41:** The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates. Variable speed control. Use with any telescope drive rated up to 12 watts. Operates from 12 v. D.C. or 115 v. A.C. .... **$135.00 ppd.**

15—**6 x 30mm VIEWFINDER—Model 631:** Actual field: 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. Bracket with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". .... **$29.50 ppd.**

16—**6 x 30mm RIGHT-ANGLE VIEWFINDER—Model 633:** As in (15), but with prism for convenient right-angle observations. Prism may be rotated 360° for maximum viewing comfort. 2-ring bracket included. .... **$36.50 ppd.**

SCHMIDT-CASSEGRAIN ACCESSORIES—The finest obtainable. For Meade and other brands.

17—Tele-Extender .... **$22.50 ppd.**
18—Rotary Eyepiece Holder (holds 4 eyepieces) .... **$75.00 ppd.**
19—2" Diagonal Mirror (1/10-wave) .... **$160.00 ppd.**
20—Off-Axis Guider Body .... **$52.50 ppd.**
21—Telecompressor (multi-coated) .... **$36.00 ppd.**
22—T-Adapter .... **$22.50 ppd.**

23—**SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼" O.D.; MULTI-COATED)**—Custom 3-element designs, precisely corrected for chromatic and spherical aberrations. Finest obtainable under $25.

FOCAL LENGTHS: MA 6, 9, 12, 25mm, 40mm Wide-Field, ea. .... **$23.50 ppd.**

24—**MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼"O.D.; MULTI-COATED)**—Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief .... **$32.50 ppd.**

25—**SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.; MULTI-COATED, PARFOCAL)**—The excellent 4-element high resolution optics of these oculars are all the majority of serious amateurs ever require. Razor sharp 45° fields. Both 1¼" and .965" O.D. sets parfocalized.

FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm .... **each $32.50 ppd.**

26—**RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**—The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. 4-element systems, unsurpassed in color correction, resolution, and flatness of field. 45° field. **OR 4, 7, 10.5 16.8, 28mm** .... **each $46.50 ppd.**

27—**RESEARCH-GRADE ERFLE EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)**—For breathtaking wide-angle observations. 65° fields, parfocalized with our Research-Grade Orthoscopics. **FOCAL LENGTHS: ER 7, 12.4, 15.5, 20mm** .. **each $54.50 ppd.**

VIEWFINDERS — With helical focusers for ultraprecise control of image sharpness. Coated, achromatic objectives of new Meade design yield fully corrected images throughout the field. Actual field on 50mm models: 4¼°, on 60mm models: 3½°. Crosshair eyepiece, dewcap, dustcap included.

28—**8 x 50mm—$52.50 ppd.** Brackets: **$12.50/pr. ppd.**
29—**8 x 50mm RIGHT-ANGLE—$59.50 ppd.** Brackets: **$12.50/pr. ppd.**
30—**GIANT 9 x 60mm—$77.50 ppd.** Brackets: **$12.50/pr. ppd.**
31—**GIANT 9 x 60mm RIGHT ANGLE—$84.50 ppd.** Brackets: **$14.50/pr.**

32—**RESEARCH-GRADE ERFLE 32mm EYEPIECE (2" O.D.; MULTI-COATED)**—Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$110.00 ppd.** Adapter Barrel for 1¼" O.D. **$12.00 ppd.**

33—**DELUXE CAMERA ADAPTERS**—Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify your camera brand and either 1¼" or .965" focuser. All 1¼" units are threaded for filters. **Nikon, Canon, Minolta, Pentax K, Konica, Olympus OM, or Universal Thread-Mount** ...... **$29.50 ppd.**

34—**2X and 3X TELENEGATIVE AMPLIFIERS (1¼" O.D.; MULTI-COATED)**—Warranted without qualification to be the world's finest Barlow lenses. Full 26mm clear apertures. Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths on any telescope. **2X Model 122:** ... **$32.50 ppd; 3X Model 123:** ... **$35.00 ppd; 2X Model 131:** Per Model 122, but for 965" focusers, 18mm clear aperture, Multi-Coated .... **$27.50 ppd.**

35—**2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)—Model 127:** Made to same research standards as Model 122 above, but mounted in a machined sliding cell, for variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated .... **$39.95 ppd.**

36—**PARABOLIC MIRRORS** — The very finest. 1/10-wave, diffraction-limited primary mirrors. Aluminized and quartz overcoated. Immediate shipment. **6" f/8 ... $69.50 ppd.; 6" f/5 ... $80.00 ppd.; 8" f/6 ... $110.00 ppd.; 10" f/6 ... $250.00 ppd.; 12½" f/6 ... $425.00 ppd.**

37—**SECONDARY MIRRORS** — Elliptical 1/10-wave flats. Aluminized and overcoated. Immediate shipment. **1.30" M.A. ... $13.00 ppd.; 1.52" M.A. ... $17.50 ppd.; 1.83" M.A. ... $21.00 ppd.; 2.14" M.A. ... $24.75 ppd.; 2.60" M.A. ... $29.50 ppd.; 3.10" M.A. ... $52.50 ppd.**

38—**ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" O.D.)**—New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete ... **$59.50 ppd.** Interchangeable barrel for .965" O.D. ... **$7.50 ppd.**

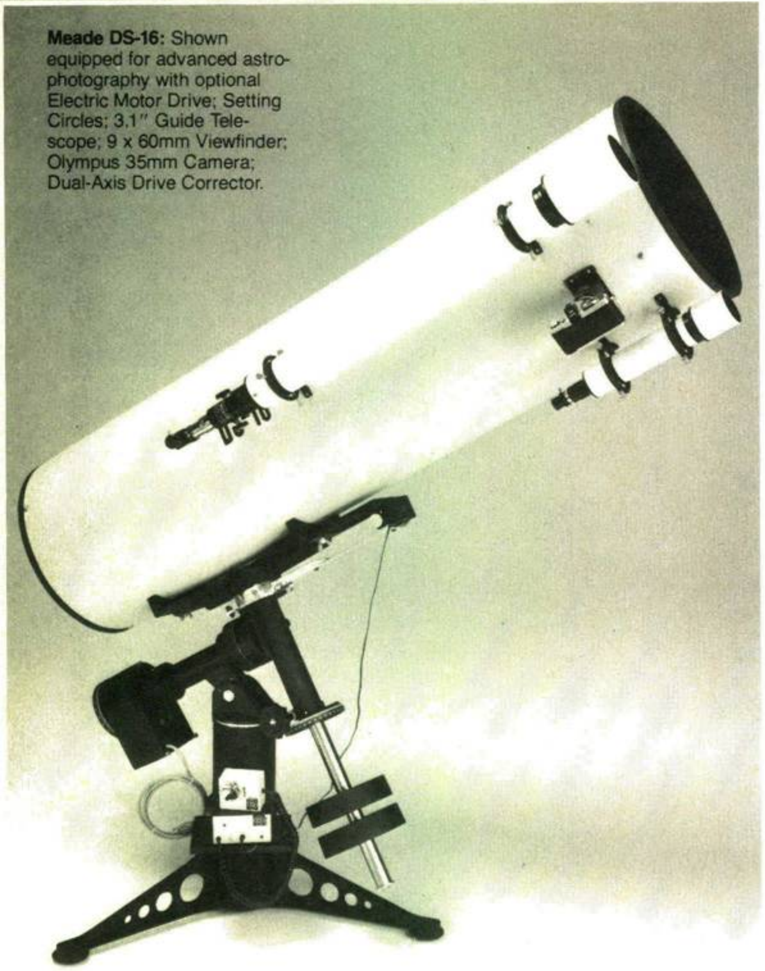
39—**MICROMETER RETICLE**—Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle of Item (38) above .... **$19.50 ppd.**

40—**ERECTING PRISMS** — Fully coated Porro prisms. Invert the astronomical image for terrestrial observations with astronomical telescopes. **1¼" O.D. ... $31.50 ppd.; .965" O.D. ... $29.95 ppd.**

DIAGONAL PRISMS—Optical-quality right-angle prisms, fully coated.

41—**Model 915:** Fits .965" focusers, accepts .965" eyepieces ... **$24.95 ppd.**
42—**Model 917:** Hybrid diagonal — fits .965" focusers, accepts 1¼" O.D. eyepieces .... **$26.95 ppd.**
43—**Model 918:** 18mm clear aperture. Fits 1¼" focusers, accepts 1¼" eyepieces .... **$24.95 ppd.**
44—**Model 918A:** 30mm clear aperture. Fits 1¼" focusers, accepts 1¼" eyepieces. Enlarged aperture increases field at low power .... **$28.95 ppd.**

Meade® 10″ f/4.5 and 16″ f/4.5 DEEP-SPACE Telescopes



Meade DS-16: Shown equipped for advanced astrophotography with optional Electric Motor Drive; Setting Circles; 3.1″ Guide Telescope; 9 x 60mm Viewfinder; Olympus 35mm Camera; Dual-Axis Drive Corrector.

"The Meade DS-16 is definitely the best astronomical investment I've ever made."

Since their introduction in early 1982, Meade 10″ and 16″ Deep-Space Telescopes have revolutionized the visual observation and astrophotography of Deep-Space objects by the serious amateur. Hundreds of these incredible instruments are now in use throughout the World, with observers continuing to report visual detail never before seen in their experience through amateur-owned equipment.

By combining giant apertures with fast f/4.5 photographic focal ratios, Meade Deep-Space Telescopes permit the capture on film of elusive nebular and galactic detail in 5-to-15 minute exposures—exposure times so short even a beginner can obtain exciting results. Visually, the Meade DS-10 and DS-16 enable observation of subtle blue-green colorations in such objects as the Great Nebula in Orion (M42); inspection of dust lanes in spiral galaxies such as M51 and M101; resolution to the core of the Hercules globular cluster (M13). And, with their rock-solid equatorial mounts, Meade Deep-Space Telescopes virtually eliminate the bothersome backlash and wobble so detrimental to serious observing.

Read what DS-10 and DS-16 owners are saying:

"Observing with the DS-10, I can not praise it enough. For the price, I don't believe it can ever be beaten. Even lunar observing has been fantastic. On deep-sky objects the sky is literally the limit. The DS-10 is also very suitable for double star observations. The wide field of view gives beautiful framing of double stars at lower powers. If you compare the DS-10 to any other scope of equal price, the DS-10 comes out far ahead. It is and will continue to be a pleasure to use."

—T. Bosler, Douglasville, PA

"I'm writing to let you know how much I enjoy my DS-16. I can finally see the detail and structure in galaxies that I've only dreamed of before. Last February I got carried away and observed 98 galaxies in one night! M101 is fantastic. The spiral arms seem to go on forever and more than a dozen HII regions are evident. The Meade DS-16 is definitely the best astronomical investment I've ever made."

—B.J. Williams, Houston, TX

SPECIFICATIONS — Meade DS-16: 16″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited, Pyrex parabolic primary mirror and matching (4.00″ M.A.) 1/10-wave flat elliptical secondary; flotation mirror cell; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (73X) eyepiece; Sonotube 18″ I.D. x 68″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth Nylon bearings, 1½″ solid steel shafts, and 5″-dia. polar thrust surface; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete **$1395** FOB Costa Mesa, CA. With #897 Electric Motor Worm-Gear Drive, add $155.

SPECIFICATIONS — Meade DS-10: 10″ f/4.5 Reflecting Telescope. With null-figured, diffraction-limited Pyrex parabolic primary mirror and matching (2.60″ M.A.) 1/10-wave flat elliptical secondary; #67 rack-and-pinion focuser at convenient observing position; Kellner 25mm (46X) eyepiece; Sonotube 12″ I.D. x 46″ long, sealed and attractively Zolatone coated; all-metal, precision-machined Equatorial Mount, with ultrasmooth nylon bearings and 1″ solid steel shafts; rock-solid, low-profile pier and tripod legs; locks on both axes. Complete **$579.95** FOB Costa Mesa, CA. With #787 Electric Motor Drive, add $75.

Meade DS-10: With optional Electric Motor Drive; Setting Circles; 6 x 30mm Viewfinder.

Toll-Free Dealer Locations & Ordering Assistance

Meade astronomical telescopes, accessories, and other optical instruments are available through hundreds of authorized dealers throughout the U.S.A. and Canada. For the name and address of your nearest Meade dealer, or for factory-direct ordering assistance, call Meade Instruments **toll-free** in the continental U.S.A. (except Calif.):

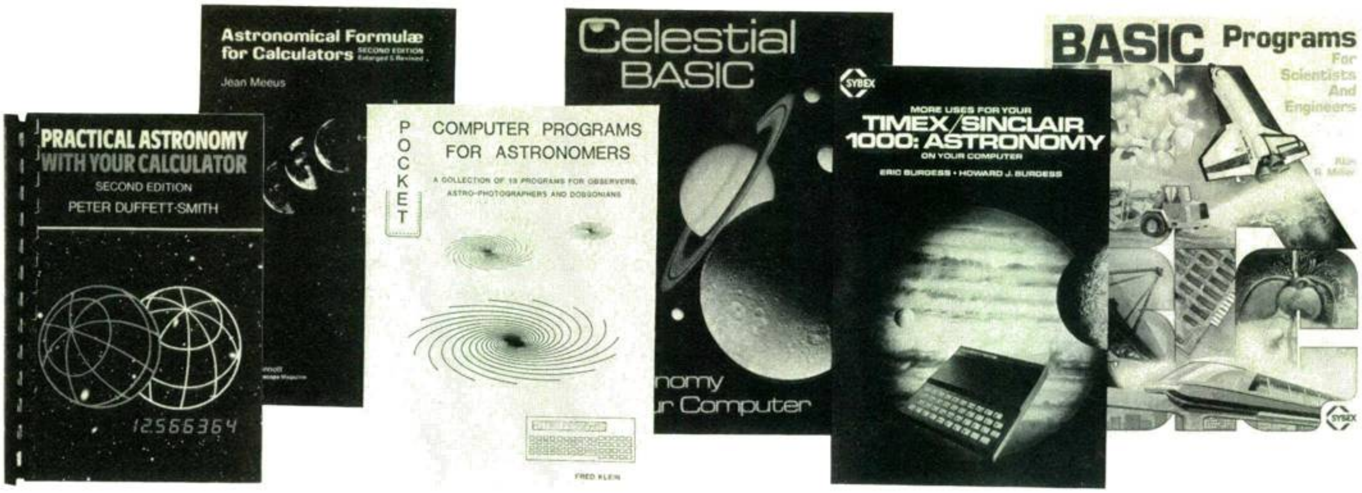
1-800-854-7485

From all other areas, including California, dial direct **(714) 556-2291.**

All-New 52-page General Catalog—$3.00

Send $3.00 for your copy of the just-revised Meade full-color **General Catalog #83C,** with complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, telescope parts, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, California 92626 □ **(714) 556-2291**


Astronomical Formulæ for Calculators
Second Edition
Jean Meeus
PRACTICAL ASTRONOMY WITH YOUR CALCULATOR
SECOND EDITION
PETER DUFFETT-SMITH
12566364
POCKET
COMPUTER PROGRAMS FOR ASTRONOMERS
FRED KLEIN
Celestial BASIC
nomy
r Computer
SYBEX
MORE USES FOR YOUR
TIMEX/SINCLAIR 1000: ASTRONOMY
ON YOUR COMPUTER
ERIC BURGESS • HOWARD J. BURGESS
BASIC Programs
For Scientists And Engineers
Alan R. Miller
SYBEX

ASTRONOMY SOFTWARE

Practical Astronomy With Your Calculator, 2nd ed., by Peter Duffett-Smith. Tells you how to use a scientific calculator to convert local standard time to sidereal time, find the time of moonrise and set — and more. Assumes no specialized knowledge, provides complete examples. 188 pages, paperback, **$10.50.**

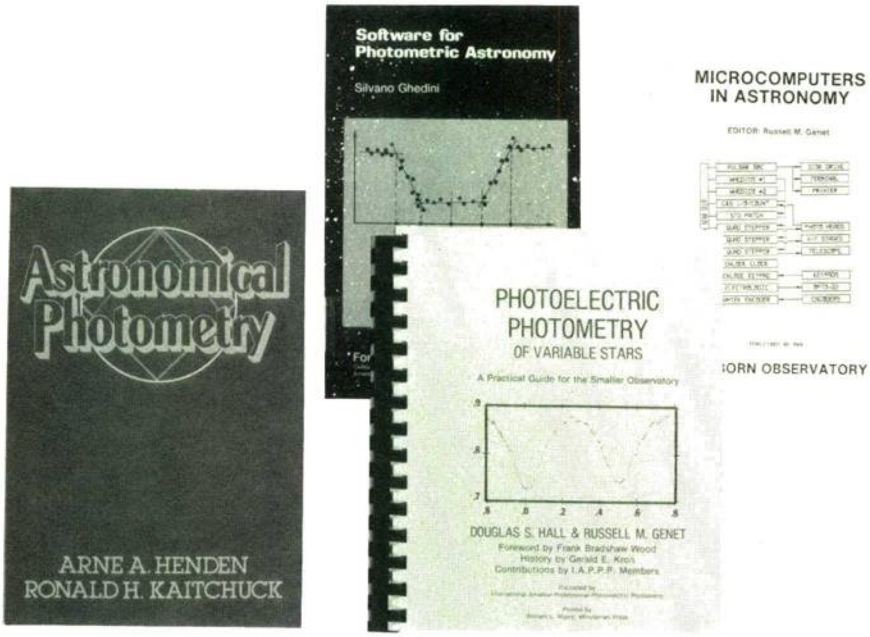
Astronomical Formulae for Calculators, 2nd ed., by Jean Meeus. For the more mathematically advanced, provides formulae for you to write programs to determine the positions of the jovian moons, the principal perturbations affecting the planets — and lots more. Fully worked-out examples. 201 pages, paperback, **$15.50.**

Pocket Computer Programs For Astronomers, by Fred Klein. Contains 13 Pocket Computer BASIC programs for calculating altitudes and azimuths, jovian satellite positions, age and phases of the Moon, comet positions, and much more. Besides the programs, it also tells you how the programs work so you can customize them for machines other than the Pocket Computer. 100 pages, paperback, **$12.95.**

Celestial BASIC, by Eric Burgess. Written for Apple II computers, but modifiable to run on other machines. Includes programs for precessing star coordinates, phases of the Moon on any date, and far more. Makes use of the Apple's graphics capability. 300 pages, paperback, **$14.50.**

More Uses for Your Timex/Sinclair 1000: Astronomy on Your Computer, by Eric and Howard J. Burgess. Contains ready-to-run programs for calculating the right ascension and declination of the Sun, the Moon, and all the planets for any date, the positions of Jupiter's Galilean satellites, elongations and phases for Mercury and Venus, and much more! 153 pages, paperback, **$9.50.**

BASIC Programs for Scientists and Engineers, by Alan R. Miller. A cookbook of mathematical routines. Includes matrix multiplication and division, solving equations, how to find a best-fit curve, sorting, numerical integration, and how to evaluate your BASIC interpreter. 318 pages, paperback, **$16.50.**


Software for Photometric Astronomy
Silvano Ghedini
MICROCOMPUTERS IN ASTRONOMY
EDITOR: Russell M. Genet
FAIRBORN OBSERVATORY
Astronomical Photometry
ARNE A. HENDEN
RONALD H. KAITCHUCK
PHOTOELECTRIC PHOTOMETRY OF VARIABLE STARS
A Practical Guide for the Smaller Observatory
DOUGLAS S. HALL & RUSSELL M. GENET

Astronomical Photometry, by Arne A. Henden and Ronald H. Kaitchuck. Written at a college text level, covers the theoretical side of photometry. In addition to covering atmospheric extinction corrections, the UBV system, absolute calibration, and constructing photometers, it details the types of variable stars and why astronomers observe them. 392 pages, hardcover, **$30.95.**

Software for Photometric Astronomy, by Silvano Ghedini. You don't have to write your own software — Ghedini has already done it. Written in HP BASIC, the programs begin with air mass and extinction corrections, then leap to determining time of minimum light and period analysis of variables. 221 pages, paperback, **$27.50.**

Photoelectric Photometry of Variable Stars, by Douglas S. Hall and Russell M. Genet. A wealth of practical hands-on advice for photoelectric photometry — from using a photometer to data reduction. Descriptions of amateur observatories and addresses of suppliers and amateur organizations included. 281 pages, paperback, **$18.50.**

Microcomputers in Astronomy, ed. by Russell M. Genet. Thirty papers presented at the Fourth Fairborn Symposium detail the present state-of-the-art in applying microcomputers to automatic telescope control. An absolute must for everyone interested in controlling telescopes or photoelectric photometers by computer. 253 pages, paperback, **$23.95.**

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Foreign orders, add $2.50.

Star PRODUCTS

BINOCULARS FOR EVERY OBSERVER!

SEE MORE WITH OUR GIANT BINOCULARS

Quality Features Found In These 80mm Binoculars:

- big 80mm achromatic objective lenses
- fully coated optics
- maximum image sharpness and contrast
- center knob for quick and easy focus
- quality optics from Celestron
- 25-year warranty
- 11½ inches high and under 5½ lbs. each
- tough black plastic finish

11x80 Country-Sky Binoculars

For the widest, brightest experiences in deep-sky observing, we recommend 11x80 binoculars. Why? Their tremendous light grasp coupled with their wide field of view will show you large faint nebulae and the glittering star clouds of the Milky Way better than small binoculars or high power telescopes. Tripod recommended for best results. Wide 4.5 degree field of view, extra-large 7.3mm exit pupil.

11x80s (without tripod)
SP111 . . . . $255.00

11x80s with tripod
SP112 . . . . $335.00

20x80 For Greater Magnification

Imagine the sparkling Pleiades imaged in the powerful twin optical systems of these big binoculars! Higher magnification brings out fainter stars and finer detail — excellent for viewing brighter Messier objects and for general astronomy. We recommend these as superior for city observing. Tripod recommended. 3.5 degree field of view, 4mm exit pupil for sharp performance.

20x80s (without tripod)
SP113 . . . . $270.00

20x80s with tripod
SP114 . . . . $350.00

We regret that we can sell this sturdy tripod only with binocular orders.

Every giant binocular comes complete with a heavy duty carrying case, shoulder carry-strap for case, Photo-Tripod Adapter (fits all tripods), and objective and eyepiece lens caps.

BUSHNELL BINOCULARS

7x35

The all-around glass — light, compact, sturdy, portable. Perfect for beginning astronomers, excellent for sports, sailing, racing, hunting as well. 9.5° field of view; 5mm exit pupil; 4⅞" high; 17 ounces.

SP108 . . . . $51.95

7x50

The traditional choice for amateur astronomers. Fantastic light grasp; 7° field of view; huge 7mm exit pupil. 7" high; weighs 27 ounces.

SP109 . . . . $64.95

10x50

Heavier than 7x50s, 10x50s offer more magnification and better definition. Wide angle eyepiece covers magnificent 8° field of view. 38 ounces; 6⅛" high; 5mm exit pupil.

SP110 . . . $169.95

All Bushnell binoculars come with carrying case and straps and feature Insta-Focus for fast, one-hand focusing. Plus a limited lifetime warranty.

Star PRODUCTS

Div. of AstroMedia Corp.
625 E. St. Paul Ave.
P.O. Box 92325
Milwaukee, WI 53202

Binoculars and accessories shipped promptly via U.P.S.

Sorry, but we cannot ship outside the U.S. except APO and FPO.

PHONE ORDERS AND INQUIRIES WELCOME.

(414) 276-7680

Send this coupon or a copy to: **STAR PRODUCTS™, Div. of AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92325, Milwaukee, WI 53202. (414) 276-7680** Phone orders welcome.

☐ SP108 $ 51.95 ☐ SP109 $ 64.95 ☐ SP110 $169.95
☐ SP111 $255.00 ☐ SP112 $335.00 ☐ SP113 $270.00 ☐ SP114 $350.00

Send me the items I have checked (✓) above.

Enclosed is my check/money order for $ ______.

Charge my credit card $ __________.
☐ MasterCard ☐ VISA ☐ American Express

Card Number ____________________ Exp. Date ______

Signature ____________________ ( ) Daytime Telephone Number ______

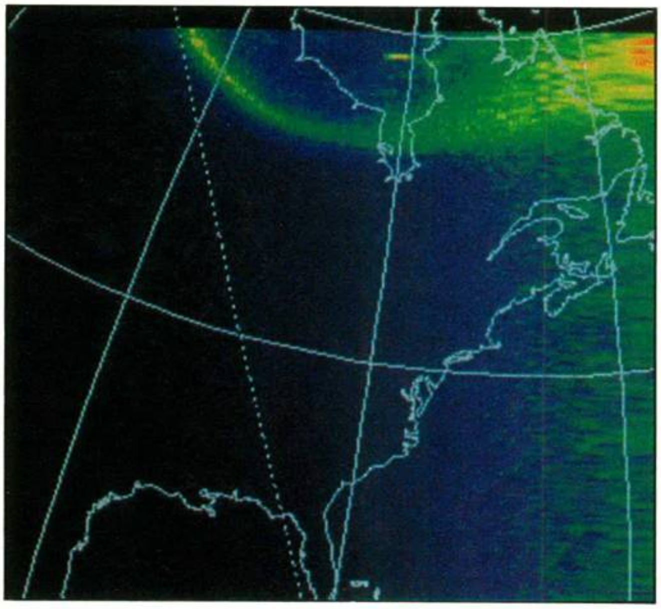
Name ____________________

Address ____________________

City ______ State ______ Zip ______

6S123

ASTRO NEWS



Crescent of colors represents an aurora over Hudson Bay. A ground computer added the colors and the map to HILAT data. The dotted line shows the terminator, the division between day (right) and night.

Daytime Aurora

Charged particles rain down on our planet day and night. Entering the upper atmosphere along Earth's magnetic field lines, they tear apart gas molecules to create the glow of the aurora. But while satellites have allowed scientists to study the rings of light on Earth's nightside (see "Celestial Winds, Polar Lights," in the August issue), detailed observations of the dayside aurora were impossible owing to the glare of reflected sunlight.

Now, however, a special device aboard HILAT, the high-latitude research satellite, allows geophysicists to watch the aurora in broad daylight. Launched in late June, the satellite was designed to observe the intense natural charged-particle activity in our planet's ionosphere. One of the five experiments it carries is the Auroral Ionospheric Mapper, which monitors the aurora's far ultraviolet emissions. These wavelengths are readily absorbed by the Earth's atmosphere. Thus intense solar radiation in these wavelengths is not reflected back into space, and energetic radiation from the 100-km high aurora appears brighter than the sunlit portion of Earth.

"The imagery meets all expectations and surpasses the required design goals," said Ching Meng, one of the scientific investigators at Johns Hopkins Applied Physics Laboratory. Along with the Johns Hopkins physicists, scientists at the Air Force Geophysics Laboratory are also interpreting HILAT's data. Continuous monitoring of the auroral zones by satellite imagers should allow scientists to observe atmospheric disturbances and provide a broad picture of the environment of near-Earth space.

San Diego *vs.* Palomar: Round 2

The battle between the city of San Diego and Palomar Observatory (AstroNews, March 1983) took a turn for the better when that city adopted use of low-pressure sodium lamps, whose light pollution is relatively easily filtered by astronomers. But in recent events, and ignoring the pleas of astronomers the world over, San Diego city officials have changed their minds and accepted bids on a high-pressure sodium lighting system that could ultimately destroy the value of Palomar, located some 60 miles north of San Diego. The dispute between the astronomers and members of the city council began in 1978 when San Diego decided to replace its 26,000 mercury vapor lamps with more energy-efficient models.

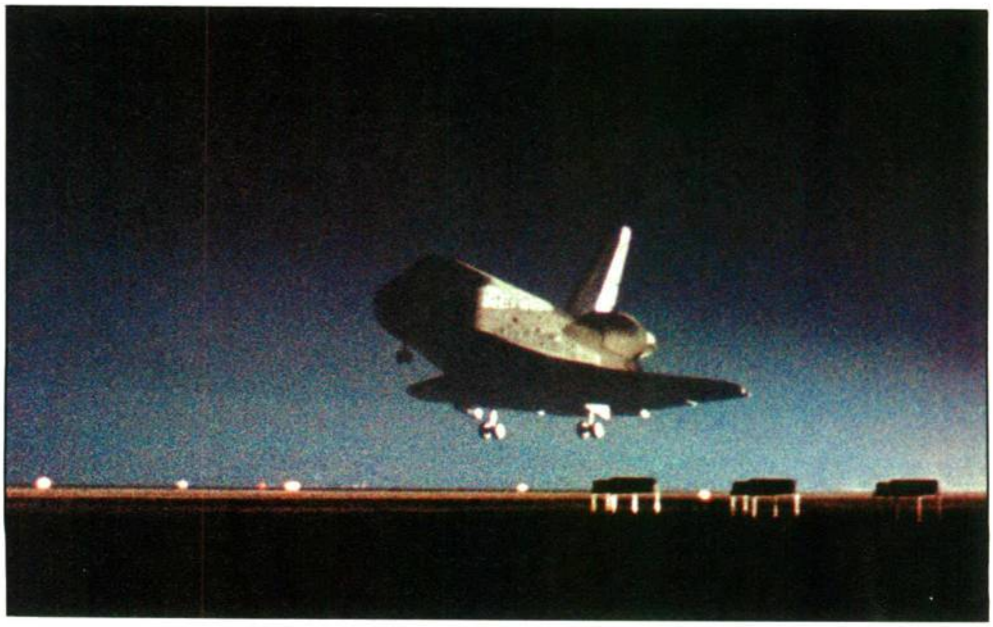
The city council says it has chosen the high-pressure sodium lights because they emit a pleasing, light-peach color, while the low-pressure sodium emits a yellowish cast which they claim disturbs many of the area's residents. "They [the astronomers] want to turn our technicolor city into a black and white city," said a city official. But the decision — apparently based solely on aesthetic considerations — poses a severe problem to the scientists. Explains a Palomar astronomer: "Low-pressure sodium is like a picket fence with just one picket. We can work around it. Mercury vapor light is like a picket fence with six or eight pickets. We can also work between its lines. But high-pressure sodium is like a brick wall. There is nothing for us to look between."

Astronomers have long wondered when Palomar may be seriously injured by light pollution, just as its predecessor Mount Wilson has been by the lights of Los Angeles. But they will not give up without a fight, which will surely occur when the San Diego city council debates the matter and discusses authorizing monies for the project in October.

Second Millisecond Pulsar Found

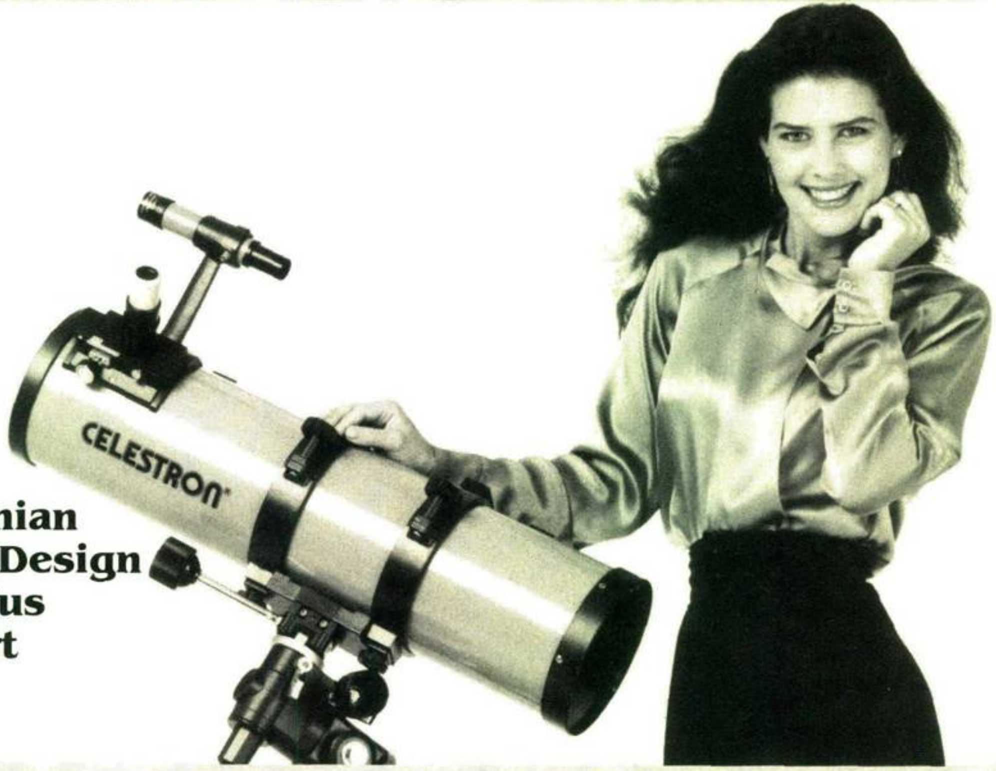
Last year, astronomers discovered a pulsar with the astonishing period of 1.5 milliseconds — the fastest known example by far. There were two possible, but mutually exclusive views of what would happen next: 1) a neutron star rotating in 1.5 milliseconds was such an exceptional object, perhaps so near a natural instability that it was an isolated phenomenon; 2) radio astronomers had neglected objects in this period range, and a flood of similar discoveries should follow.

So far, astronomers have found only one similar object — a pulsar with a period of 6.1 milliseconds



Beaming white lights illuminate Runway 22 at Edwards Air Force Base in California, the scene of the first nighttime landing of the Space Shuttle, made at 12:40 a.m. (PDT) on September 5, 1983. The six-day mission's happy passengers were commander Richard H. Truly and astronauts Daniel C. Brandenstein, Guion S. Bluford, Dale A. Gardner, and William E. Thornton. NASA photo.

NEWTON WOULD BE ASTOUNDED



Celestron's New C6 Newtonian Offers Classic Design Advantages Plus State-of-the-Art Advances

The Classical Newtonian Reflector offers excellent light-gathering ability, wide field of view, good portability and excellent price. The Newtonian design has not been significantly improved upon since 1668. Celestron's new Classic C6 Newtonian is a telescope that Sir Isaac would instantly recognize at a distance. But up close, he would be astounded.

The C6 is no ordinary 6" Newtonian. It is the best Newtonian ever manufactured. It features multi-coated mirror surfaces for 20% greater reflectivity than ordinary 6" Newtonians. Celestron quality diffraction limited optics. It offers an f/5 ratio for outstanding brightness and fantastic ease in astrophotography. An incredible high-contrast 26mm Plössl eyepiece. An equatorial mount with slow-motion controls, setting circles on both axes, adjustable threaded counterweight, azimuth and elevation adjustment and a tripod with easy height adjustment and accessory tray. Plus a fully achromatic wide-angle 6X30 finderscope.

But there's more. Including an optional IC controlled quartz pulse motor drive with drive corrector. And optional Polar Axis Finder Scope for precision polar alignment in minutes. A whole world-renowned Celestron line of adaptors, oculars, mounts, filters and accessories.

And a 25-year limited warranty as good as our name.

An ordinary Newtonian 6" is a good telescope at a great price. The new Celestron is a great improvement at a great price. Find out more. Contact your nearest Celestron Dealer.

CELESTRON®
PRECISION OPTICS

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

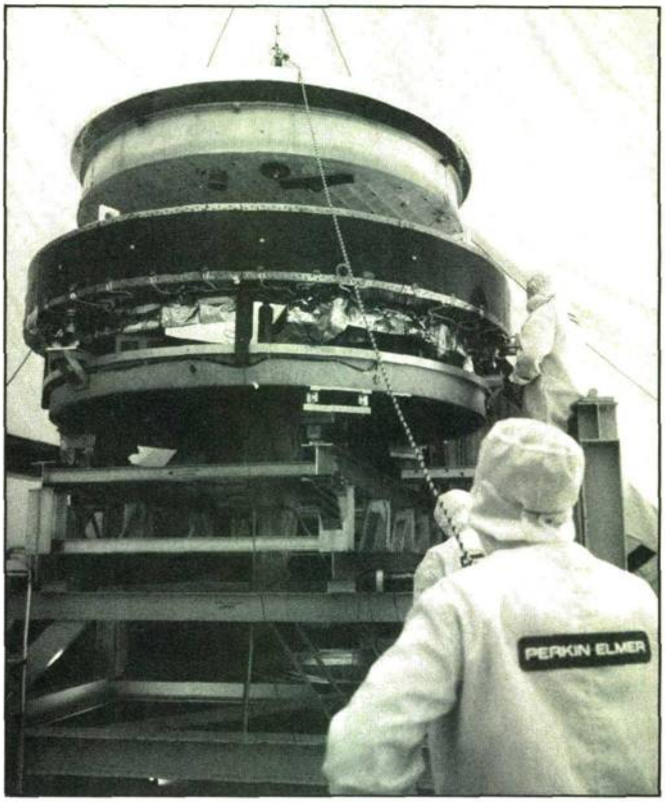
(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578 B11, 2835 Columbia St., Torrance, CA 90503 (213) 328-9560 discovered by V. Boriakoff of Cornell University, R. Buccheri of the Institute of Cosmic Physics in Palermo, Italy, and F. Fauci of the University of Palermo. The pulsar has a stellar companion (believed to be a 0.3 solar mass white dwarf) with an orbital period of 120 days.

Most pulsars have periods measured in seconds, which means that the neutron star that creates the pulsed radiation we detect completes one rotation in a matter of seconds. This would be impossible but for the incredible binding energy of the impossibly crushed atoms that make up the neutron star. The rotational speed of a neutron star is limited not so much by its ability to withstand the forces of rapid rotation as by the rate at which it would lose energy by emitting gravitational radiation. This radiation is caused by readjustments of the neutron star's shape; the period of the 1.5-millisecond pulsar is near the minimum period predicted by general relativity.

Although more conventional pulsars slow down at a rate rapid enough to be measured easily, the millisecond pulsars show very small decelerations. Pulsars are also expected to have extremely intense magnetic fields. But deceleration of the neutron star is a result of interactions between matter and its magnetic field. And the slow decelerations observed in the millisecond pulsars suggest a relatively weak magnetic field.

While there are still many unanswered questions, the discovery of the 6.1-millisecond pulsar reinforces a growing opinion in the astrophysical community. Astronomers now believe that there may really be two varieties of neutron star — those formed in supernova explosions having strong magnetic fields and modest periods, and those formed by the accretion of matter onto white dwarfs.



NASA's Space Telescope took a big jump ahead recently when technicians installed the 1,800 pound, 96-inch primary mirror into its holding cell. Simulating a zero-gravity environment, the technicians tested the assembly and found no strain. This assures that the mirror will stay precisely aligned on its six flotation points when in orbit around Earth. The project's director, William Raiford, said it was like "constraining a soap bubble at six points without deforming it in any way." Space Telescope is scheduled for launch late in 1986. Courtesy Perkin-Elmer Corporation.

National Optical Observatories Founded

John T. Jefferies, the man who founded the University of Hawaii's Institute for Astronomy — an astronomical research facility that many claim is among the best in the country — has been chosen as the first head of the new National Optical Astronomy Observatories (NOAO), which will have its headquarters in Tucson, Arizona.

Three observatories — Kitt Peak in Arizona, Sacramento Peak in New Mexico, and Cerro Tololo in Chile — have been loosely connected in the past, but now they have been organized into a single operation with Jefferies as chairman. NOAO will help the three observatories set priorities, lobby for funding, and allocate resources more effectively. The day-to-day operations of each institution, however, will remain as before — essentially independent of each other.

Jefferies has a track record of successful projects. He came to the University of Hawaii in 1964, when all that the state had was a fledgling solar observatory atop Mt. Haleakala on the island of Maui and a small optical telescope, connected with the University of Arizona, at Mauna Kea on Hawaii. Astronomy as a discipline had no home of its own in Hawaii and was simply an adjunct of the university's Institute of Geophysics.

Almost immediately, Jefferies wangled $3 million in federal funds to build a new telescope at Mauna Kea and began to assemble a group of astronomers. Nineteen years later, Jefferies's position as head of the Institute for Astronomy is considered one of the top astronomy posts in the country. Virtually all of its researchers have made names for themselves in their respective fields.

In his new position as head of the National Observatories, Jefferies will have a great influence on the future direction of astronomy and the development of major facilities, including the National New Technology Telescope project. *Robert Watts.*

IRAS News: Tempel 2 and Vega

The Infrared Astronomical Satellite (IRAS), the joint United States/United Kingdom/Netherlands project, has made another significant discovery during its infrared scan of the sky. The device recently detected a 20-million-mile-long tail of debris trailing behind Comet Tempel 2. The sighting surprised astronomers because no tail has ever been observed associated with Tempel 2, a periodic comet that swings around the Sun about once every five years.

As IRAS routinely scanned the skies detecting heat — infrared energy — from various sources, it reported a large number of objects apparently traveling across the sky together. Given the chance to analyze the data at the Rutherford Appleton Laboratory in Chilton, England, John Davies — an IRAS scientist from the University of Leicester — recognized that the sources must be a long thin tail. The particles making up the tail are warmed by the Sun just enough to radiate in the infrared, producing a 200,000-mile-wide streak of dust.

Based on this finding, astronomers now think that many short-period small comets — like Tempel 2 — may have tails that are visible in the infrared but optically invisible from Earth. A number of observatories plan to photograph Tempel 2, searching for evidence of a visible tail.

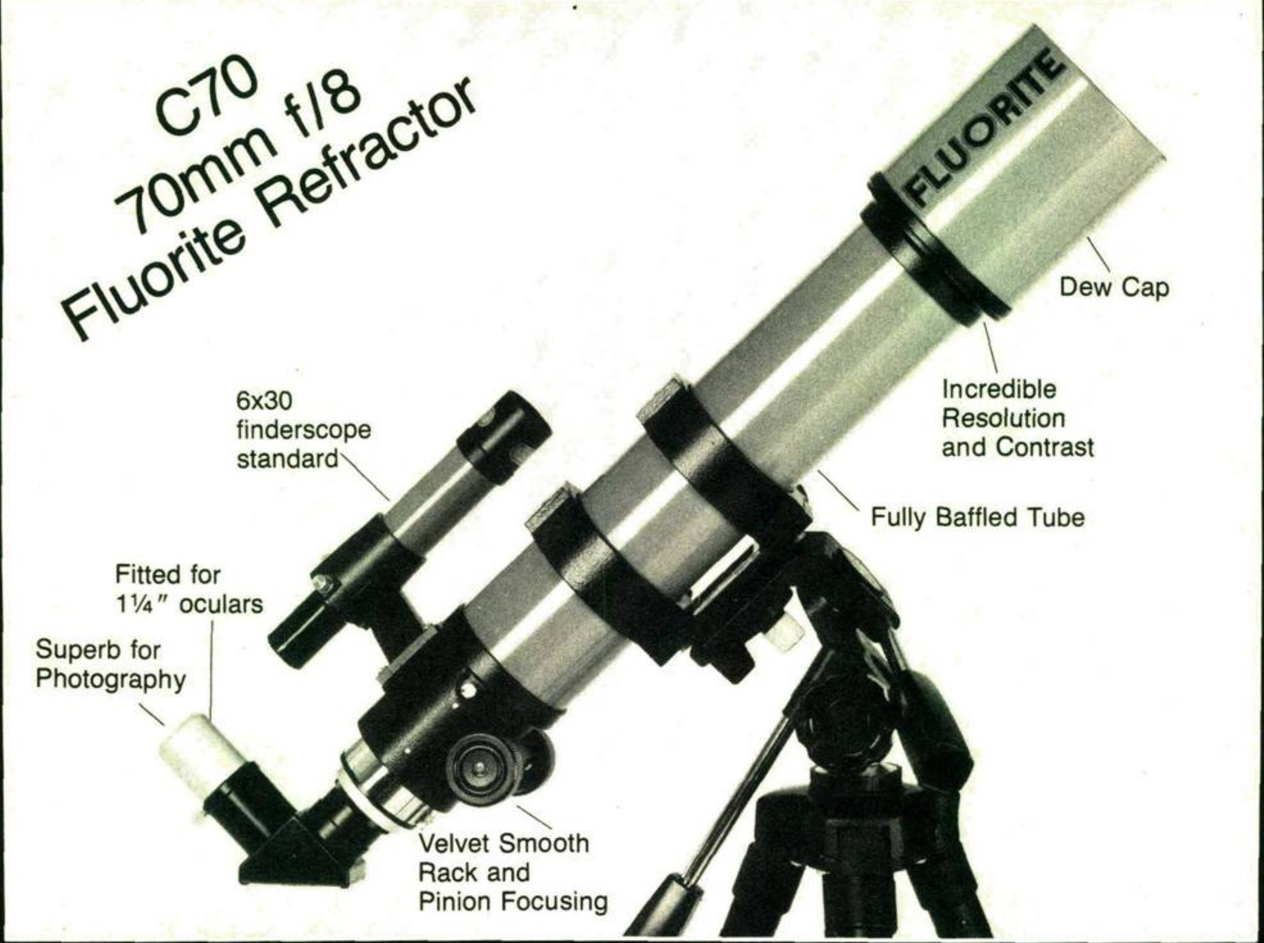
Perhaps the most outstanding discovery IRAS has made thus far was that of a ring of warm particles orbiting the star Vega, perhaps indicating the presence of an infant solar system. Soon after the early August discovery, a team of University of Texas astronomers, using the Kuiper Airborne Observatory, confirmed the IRAS findings with an onboard infrared telescope of their own. "I think the findings are exciting in the sense that the dust particles are bigger [than others previously found], and something caused them to grow bigger," said Paul M. Harvey, leader of the Texas team. Elaborating, Harvey said, "It is the relatively small diameter of the cloud for its observed temperature which is most unusual; any type of dust grain observed near other stars would reach a much higher temperature if placed at the observed distance from Vega.

"This tells us that the dust grains around Vega must be able to radiate away the heat they receive from Vega much more efficiently than any dust previously observed in interstellar space."

From this astronomers conclude that the grains are at least several hundredths of a millimeter in diameter, about 100 times larger than interstellar dust. Some process around Vega enlarged the particles

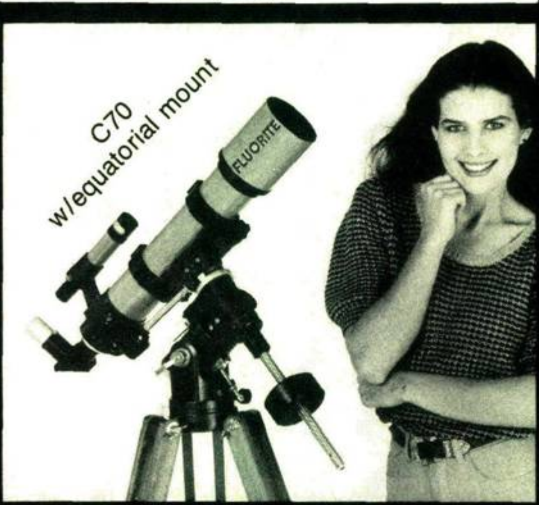
FLUORITE REFRACTORS

NOW AT YOUR CELESTRON DEALER!


C70
70mm f/8
Fluorite Refractor
FLUORITE
Dew Cap
Incredible Resolution and Contrast
Fully Baffled Tube
6x30 finderscope standard
Fitted for 1¼″ oculars
Superb for Photography
Velvet Smooth Rack and Pinion Focusing

WHY A FLUORITE TELESCOPE?

Celestron, the world's largest manufacturer/supplier of quality telescopes, is proud to unveil a new telescope - the C70 *Fluorite* Refractor Telescope. Refractors have traditionally been frowned upon because of "chromatic aberration". Modern refractors have achromatic lenses to control this aberration, but, for "perfect" images you need either more lens elements (usually at much higher cost) or a material called *Fluorite* which until now has only been available in extremely expensive telescopes. The Celestron Fluorite Refractors have a lens element from Fluorite that lets Celestron offer you a telescope with exceptional contrast and resolving power at a reasonable price. The Celestron Fluorite Refractors aren't for everybody, they're for people who want a perfect image. To look through one, see your local Celestron dealer. Other sizes (55mm, 80mm, 90mm diameter) available on special order.


C70
w/equatorial mount
FLUORITE

Questions? Call Celestron's Telescope Information Service Toll Free Continental USA Only

1-800-421-1526

Please call or write for dealer locations, catalogs or technical specifications
CELESTRON INTERNATIONAL - P.O. Box 3578-B9 - 2835 Columbia Street - Torrance, CA 90503 (213) 328-9560

PRECISION OPTICS FROM CELESTRON®

ASTRO NEWS

to their present size — perhaps the same coalescing process that took place early in the formation of our own solar system.

Mars: A SETI Lighthouse?

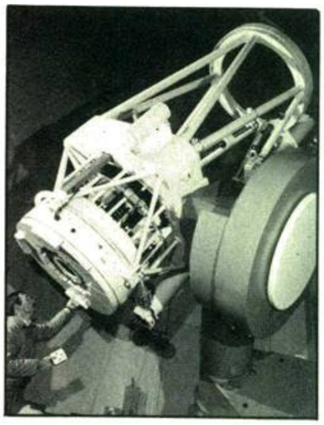
In 1980, scientists found evidence for a natural laser operating in the martian atmosphere. At an altitude of about 70 kilometers, conditions in the atmosphere are just right for sunlight to stimulate the enhanced emission of radiation from carbon dioxide molecules. Powered by the Sun, the atmospheric laser continuously operates on the dayside of the planet. The laser was detected by the brightness of its radiation at 9.4 and 10.4 microns.

Now two of the discoverers of the martian laser, Drake Demming and Michael Mumma of NASA's Goddard Space Flight Center, suggest that the planet could be used as a super-lighthouse for SETI, the search for extraterrestrial intelligence. Although the natural amplification that occurs in the atmospheric laser is small by laboratory standards, both the volume of gas undergoing the laser process and the total energy deposited by the Sun are vast compared to laboratory lasers.

Unfortunately, the natural laser's output is diffuse, its energy distributed over the whole sunlit hemisphere. In order to concentrate a portion of it, Demming and Mumma suggest placing two mirrors, each 10 km in diameter, in synchronous orbit about Mars. The mirrors must face each other so that the path between them includes the "lasing" portion of the atmosphere; they must also be placed perpendicular to incoming solar photons. The mirrors make up a resonant cavity — each time the stimulated CO_2 emissions reflect from one mirror to the other, they pick up a bit more energy. A third mirror could direct the beam to interstellar targets.

According to Mumma, a 10-km mirror system could produce a laser beam with up to 80 million watts of power. With a 10-meter telescope, an alien eye could see a one-second burst from the beacon from a distance of 55,000 light-years. Mumma notes that the martian laser would be an ineffective death-ray, even with 10-km mirrors. Aimed at Earth, the beam would cover an area of 14 km, but would only have an energy density of 0.4 watt per square meter — just enough to warm your hand.

Mumma, Demming, and colleagues also report that Venus apears to have a similar atmospheric laser, though one less efficient than the martian version.



A new one-meter British southern optical telescope is about to be installed on the island of La Palma, one of the Canary Islands. Its primary purpose will be to study the brightnesses and colors of stars and galaxies, concentrating on spectroscopy and photoelectric photometry. It will be controlled by computer from the Royal Greenwich Observatory in England — some 1,800 miles away. The observatory is a cooperative effort of the British, Spanish, Swedish, Danish, and Dutch governments. Royal Greenwich Observatory photo.

ASTRO CALENDAR

November 17-19	**IAPPP-Dyer Observatory Symposium,** photoelectric photometry meeting. Host institution, Vanderbilt University. Contact: Douglas S. Hall, Dyer Observatory, Vanderbilt University, Nashville, TN 37235. Phone (615) 373-4897.
January 8-11, 1984	**163rd Meeting of the American Astronomical Society** (professional meeting), Las Vegas, Nevada. Sponsored by the University of Nevada-Las Vegas. Contact: AAS, 1816 Jefferson Pl., N.W., Washington, DC 20036.
February 17-19	**"Astron" Exhibition/Congress,** Milan, Italy. Contact: Comis Lombardia, Via Boccaccio 7, 20123 Milan, Italy.
April 5-8	**National Meeting of the National Science Teachers Association,** Boston, Massachusetts. Contact: N.S.T.A., 1742 Connecticut Ave., Washington, DC 20009. Phone (202) 328-5800.
May 5	**Astronomy Day.** For more information, contact: Gary Tomlinson, Astronomy Day Coordinator, Astronomical League, Chaffee Planetarium, 54 Jefferson S.E., Grand Rapids, MI 49503. Phone (616) 456-3985. The Astronomical Association of Northern California will be hosting Astronomy Day on April 7.
May 30-June 3	**Texas Star Party,** Fort Davis, Texas. Contact: TSP '84, Dept. A, 128 N. Commerce, Burleson, TX 76028.
August	**6th World General Assembly of International Union of Amateur Astronomers.** Bologna, Italy. Contact: Dr. Luigi Baldinelli, c/o A.A.B., Casella Postale 1630 AD, 1-40100 Bologna BO, Italy.
August 6-10	**Spitz Space Systems' Summer Institute in Planetarium Education,** Chadds Ford, Pennsylvania. Contact: 1984 Planetarium Summer Institute, Spitz Space Systems, Inc., Route One, Chadds Ford, PA 19317.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

ASTROMART

AstroMart listings are free to all our readers, but we can allow only 2 per person per year. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

ANNOUNCEMENT — The Goddard Astronomical Society of Middlesex County, Massachusetts, meets on the second Sunday of each month at 7:30 p.m. Programs include speakers, weekly observing sessions, newsletters, field trips, and telescope workshops. We offer a unique alternative to the larger, more formal societies. Contact Guy Wright, 39 Pleasant St., B-17, Northborough, MA 01532. Phone (617) 393-6281.

ANNOUNCEMENT — The Society of Amateur Radio Astronomers (S.A.R.A.) offers publications, training aids, assistance, and a monthly newsletter to members. For information, send long SASE to S.A.R.A., 1548 Bell Flower Ct., Stone Mountain, GA 30088.

ANNOUNCEMENT — Wehr Astronomical Society meets monthly at Wehr Nature Center in Whitnall Park, Hales Corners, Wisconsin. Instruction presented on various aspects of astronomy plus outdoor telescopic viewing. A good place for the beginner to learn; an excellent opportunity for those with expertise to share. For information, contact Karen White, 5879 S. 92nd St., Hales Corners, WI 53130. Phone (414) 425-8551.

WANTED — Urgently need Miranda Laborec camera. Contact Robert Slone, 204 N. Midland Ave., Nyack, NY 10960. Phone (914) 358-3164.

WANTED — Space buffs to register for "The Great Shuttle Giveaway," a payload of shuttle books, posters, pictures, etc. For information and free mini-posters, send a business-size S.A.S.E. to Florida Spaceweek Committee, 993 Macco Road, Cocoa, FL 32922.

ADVERTISER LISTING

ADVERTISER	PAGE
Ad-Libs Astronomics	48
Astro Cards	72
Astro-Optics	65
Bushnell	29
Cambridge Univ. Press	27
Celestron Int.	61,63,88
Cotton Expressions	72
Coulter Optical	31
Edmund	48
Hirsch, Edwin	65
Jim's Mobile Ind.	65
Linaze Ltd.	74
Lumicon	34
Meade Instruments	2-3,55,56-57
Meteorites	73
Orion	71
Optica b/c	72
Optron	73
Ottewell, Guy	27
Royal Astron. Soc. of Can.	72
Scienta, Inc.	74
SkyLog	65
Sky Scientific	74
Spherical Concepts	48
Star Products	25,30,59
Star Tracker	74
Sunstone	49
TeleVue	86
Texas Nautical	74
Tomlin Industries	72
Tuthill, Roger	23
Wack Electronics	72

WANTED — Any Space Shuttle die-cast metal toys. I will pay shipping. Contact 4471 W. Sirius Ave., Las Vegas, NV 89102. Phone (702) 362-3057.

WANTED — December 1982 issue of ASTRONOMY. Contact Jeff Gebhart, Box 202, Mankota, Saskatchewan, Canada, S0H 2W0. Phone (306) 478-2671.

WANTED — Books and publications on meteorites. I'll pay shipping. Contact Paul Rusnak, 300 N. 5th St., Reading, PA 19601.

WANTED — Meade DS-10 in good condition, preferably with clock drive. Contact Dave Schneidenbeck, Rt. 39 RR 1, Box 574AA, New Fairfield, CT 06810. Phone (keep trying) (203) 746-7166.

WANTED — Information on a Maksutov telescope manufactured by the 3B Optical Company of Gibsonia, Pennsylvania, about 1965. 12½", 10" clear aperture, certification number 041465. Any optical specification or a user's manual (or a xerox copy) would be appreciated. Contact Sharon E. Etheridge, P.O. Box 278, McAllen, TX 78501.

RECORD YOUR OBSERVATIONS WITH
SKYLOG
ASTRONOMICAL RESEARCH NOTEBOOK

SKYLOG
SKYLOG

EVERY SKYLOG CONTAINS

- **50 pages of heavy card stock resist damp air.**
- **List of brilliant double stars with coordinates and description.**
- **Complete Messier Catalogue.**
- ***Greek Alphabet reference for ease in identifying stars.***
- **The 20 brightest stars for setting circle calibration.**
- **Selected list of NGC objects with coordinates.**
- **Heavy, weather resistant binder with classic silver lettering (not a plastic or vinyl binder).**

FOREIGN ADD 10%
$19.95 Complete

Please send ______ copy(ies) of SKYLOG at $19.95 each (Add $1.50 postage.)

Send check or money order to:
SKYLOG
2400 Tres Lane
Virginia Beach, Virginia 23456

Name ______
Address ______
City ______
State ______ Zip ______ A

WANTED — NASA photos and reading matter. Will trade my NASA materials for yours. Send a list of yours and/or a request for my list with an SASE to Bob Schwartzmiller, P.O. 75, Pitcairn, PA 15140.

FOR SALE — Back issues of ASTRONOMY, *Sky & Telescope, Astrograph, Review of Popular Astronomy, Scientific American, Smithsonian, National Geographic, Natural History, Audubon*, etc. Singles and/or full years. Send want list to F. Michael Witkoski, P.O. *Box 624, Camp Hill, PA 17011. Phone (717) 938-4878.*

FOR SALE — Photographer's dream 35mm camera outfit. Six lenses from 28mm to 1000mm. Paid $3050. Make offer. Only serious inquiries, please. Contact Brad Dischner, 4146 Melrose #6, Riverside, CA 92504. Phone (714) 687-4009.

FOR SALE — ASTRONOMY back issues, complete set from first (premier) issue through December 1983. Make dollar offer or suggest *item to trade. Contact David Hibner, Waterhole Rd., Colchester, CT* 06415.

FOR SALE — Large German equatorial mount. Cave heavy-duty model, 1.5" steel shafts, one of the last produced. Complete with drive, circles, portable pier on casters, cradle for 12.5" instrument. Never used. $400, you pay shipping. Contact John Bortle, Gold Road, Stormville, NY 12582.

FOR SALE — Meade 826 8" f/6 reflector, includes three eyepieces, equatorial mount, pier, tripod legs, motor drive, deluxe #680 focuser, 8x50mm finder and dust covers. One year old, in excellent condition, $525 plus shipping. Contact Andy Clements, RR#1, Box 247, Waverly, KY 42462.

FOR SALE — Edmund 6" f/6 reflector with clock drive, 8mm, 15mm, and 28mm RKEs, and variable power Barlow, all in case. Also, *Sky Atlas 2000.0*. All in top condition. For more information, contact C.R. Zadora, 555 Prince Edward St., Clermont, FL 32711.

NEW ENGLAND ASTRO-OPTICS
Your one-stop source for
QUESTAR - MEADE - TELE VUE - COULTER
free literature
23 Grimes Lane
Simsbury, CT 06070
(203) 658-0701
or Source TCU685 MNET 70055,205

CELESTRON SUPER 8
Byers Worm Gear Drive • Certified Optics

MEADE REFLECTORS & CASSEGRAINS
Long Exposure Drive Systems

BAUSCH & LOMB "CRITERION"
4000, 6000, and 8000 Series

TELEVUE EYEPIECES
Plössls • Naglers • Wide Fields

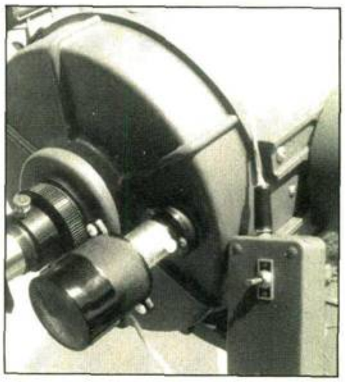
DAYSTAR H-ALPHA SOLAR FILTERS

COULTER ODYSSEY
Dobsonian Telescopes

Edwin Hirsch
168 Lakeview Dr. RR 2
Tomkins Cove, N.Y. 10986
(914) 786-3738

Demonstrations in my Observatory

AT LAST!! NO MORE WIGGLES FOCUSING



Direct drive remote control focusing with electro-magnetic braking
No gears or belts to install
Excellent for astrophotography
Installs in 45 seconds
C-8 no drilling or tapping — $55.00
All Meade Newtonian and Novak Newt. and Cass.require drill and tap — $49.95
PPd. U.S.A. Battery incl.
VISA, Mastercard, check. **(303) 277-0304**

JIM'S MOBILE IND.
1960 Co. Rd. 23
Evergreen, CO 80439

The Search for Life on Mars: Shots in the Dark

by Linda J. Strand

Lunar and Planetary Lab.

For centuries, Mars has been an object of speculation and controversy, much of which centered around the possibility that some form of life might exist there. In the years leading to the landing of the Viking Mars probes during the summer of 1976, the Red Planet was the object of great hope among both the scientists who had dedicated up to 10 years of their lives to the success of the mission and lay observers listening to the latest developments on the evening news.

Today, over seven years after spacecraft beamed back the first photographs from the martian surface, this neighboring planet continues to perplex the scientific community. Everyone wanted a definite yes or no to the question of life on Mars, but that answer never came. For those patient enough to look into the details, the underlying ambiguity of Viking's search for martian life speaks louder than any conclusions drawn from its data. Although few if any of the key scientists involved in the search would today openly avow continued optimism, there are even fewer who would confidently rule out the possibility that *something* may live on Mars.

Mars: An Overview

While there were some surprises from Viking observations of the martian atmosphere and surface, scientists knew enough about the planet from previous missions to establish that it would be a difficult environment for life as we know it.

Perhaps the most serious obstacle to life is the extremely low atmospheric pressure at the surface — about 7.5 millibars, less than $\frac{1}{100}$ the surface pressure on Earth. The pressure of water vapor in the martian atmosphere is no more than 0.05 mb — far below the 6.1 mb required for the existence of liquid water on the surface. Thus, if anything that might be described as "living" exists on the surface of Mars, it could *not* be dependent on abundant liquid water for sustenance.

Another considerable challenge to life as we know it was also well known before the Viking mission. Mars has no ozone layer to screen out lethal ultraviolet radiation from the Sun. Unshielded radiation between 1900 and 3000 Angstroms breaks down organic molecules in very short order, presumably before any kind of reproduction can take place. While this is not an insurmountable obstacle to the development and survival of life, scientists knew that martian organisms would probably not be found basking atop the desert sands.

In addition, Mars is a very cold place, by terrestrial standards. For example, the diurnal temperature range on the Plain of Chryse where Viking Lander 1 is located typically went from −81° C to −33° C. That's not only cold, it's a daily temperature range of nearly 50° C! Although it would take a durable lifeform indeed to withstand such environmental variations, there is still nothing here that excludes biology. On Earth, organisms have developed ingenious adaptations to counteract extreme environmental temperatures, from built-in antifreeze to dormancy during periods of intense cold.

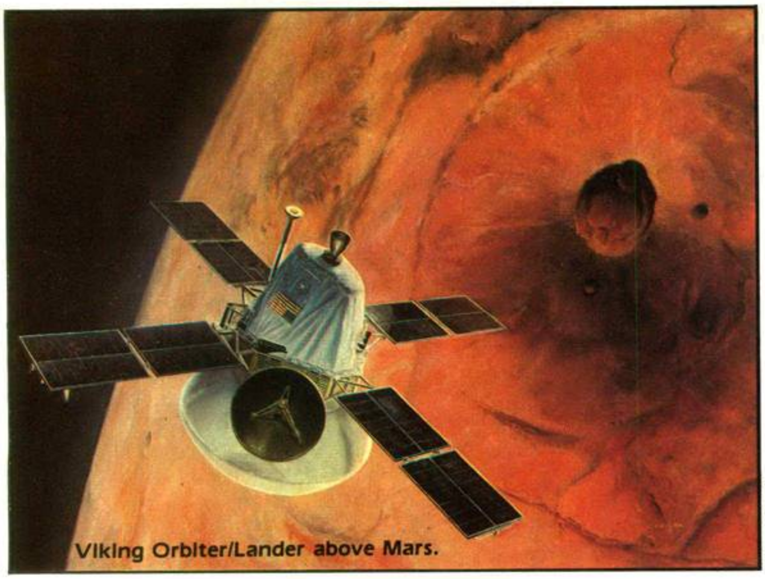
Scientists have long known that the martian atmosphere (what there is of it) contains about 95 percent carbon dioxide. While noxious to us, it may be ideal to different biochemistries. One of the more encouraging findings of the Viking mission was the presence of 2.5 percent nitrogen in the atmosphere near the surface — important, if not indispensable, for the existence of life. All of the amino acids, the "building blocks" of life on Earth, contain nitrogen; therefore it is presumed to be a crucial element to the processes of life. In fact analyses of the soil indicate the presence of calcium, sulfur, magnesium, and chlorine, as well as the probable existence of potassium and phosphorus — all likely to be important to living things.

Although the existence of water in liquid form on the martian surface is highly improbable at present, that does not exclude the possibility that it may exist either as ice or water vapor. There are small amounts of water vapor in the martian atmosphere, but scientists estimate its contribution as less than one percent of the total make-up. One of the surprises from Viking's orbital observations was the discovery that the martian polar caps were not carbon dioxide as previously believed, but actually water ice alternately covered and exposed by a seasonal layer of frozen carbon dioxide. The amount of water locked up in the caps is not known — so far, there is no way to estimate it because the thickness of the ice layer cannot be measured from orbit. In addition, planetologists have suggested that water locked up in the form of permafrost — a layer of water-saturated frozen ground just below the surface — may be an important reservoir.

While the relevance of this frozen water to present life is questionable, it does have important implications for the possibility of martian life in the past. There is excellent geological evidence that a considerable amount of liquid water once flowed across the dusty martian plains. The time of this "wet period," and the amount of water involved is at present still largely guesswork. But estimates based on several lines of evidence imply that Mars may once have been *covered* by a layer of water 10 to 30 meters thick. If this is true, then Mars has undergone a drastic climatic change. The cause of this change is open to speculation. The important factor for living creatures is the speed of the change: Was it sudden or gradual? *If* liquid water existed on the surface of Mars long enough for life to develop, and *if* the subsequent climatic changes were relatively slow, then any life in existence could have had time to adapt to the changing environment. Perhaps martian organisms could have evolved which depend upon the conditions now prevalent on the planet.

If this is true, then they would certainly have been killed by the experiments designed to detect them aboard Viking.

While the previous scenario isn't very likely, we don't know



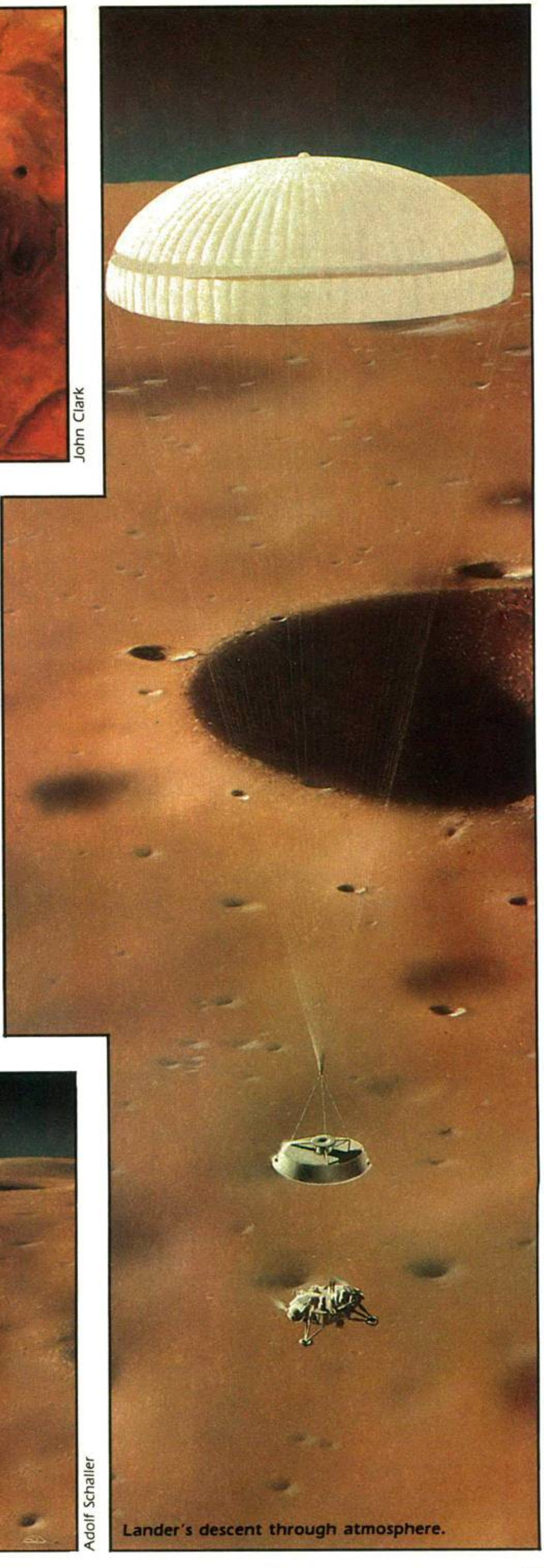
Viking Orbiter/Lander above Mars.

John Clark

— and can't know — the factors that determine the development of life until we have more than our own biology to base the generalizations on. Our understanding of life and living systems is based on observations of but a single example. We have no way of knowing which aspects of the life we observe are universal and which are accidental. One event could sweep our understanding of biology beyond this impasse virtually overnight — the discovery of extraterrestrial life.

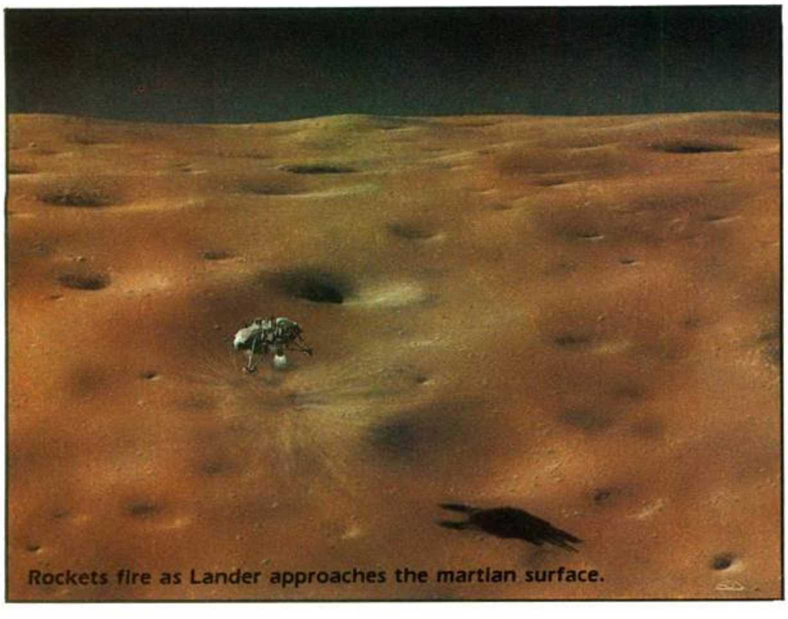
In 1964, Princeton University, under the auspices of the Space Science Board of the National Academy of Sciences, held a conference with the expressed purpose of developing proposals for the search for life on Mars. The problem of defining the object of such a search was briefly addressed by David Mazia: "The problem is not that our conception of a living thing is vague; on the contrary, our concern is that it is too definite because it is too provincial." He goes on to enumerate what he believes to be the characteristics of living systems — an enumeration which, if it is not vague, is at least as inconclusive as Viking's biological results later proved to be. Carl Sagan, in his *Encyclopaedia Britannica* article on "Life," observed that "the existence of diverse definitions of life surely means that life is something complicated."

Admittedly, life is not easy to define. In the absence of greater understanding, practically any definition is sure to initiate controversy. The potential for misapprehension is illustrated by



Lander's descent through atmosphere.

Adolf Schaller



Rockets fire as Lander approaches the martian surface.

Adolf Schaller

Sagan's example of a visitor to our planet for the first time, who might well conclude that the dominant life-form on Earth is that large metal beast commonly known as the car.

At the time the Viking experiments were being considered, the scientists involved had reconciled themselves to searching for organisms resembling those with which they were familiar — i.e., carbon-based organisms with a chemistry and metabolism fundamentally similar to terrestrial life. This imposes at the outset obvious limitations on the significance of any findings of experiments so designed — especially in the eventuality of a negative result — but it's easy to understand the reasons for this choice. It's difficult enough to design an automated experiment to search for something familiar in unfamiliar surroundings. To search for something unfamiliar would approach impossibility.

Thus, in the end, the ambiguity remained unresolved. The decision was made, essentially, to spend one billion dollars and years of dedicated effort in order to send a magnificent piece of technological handiwork 314 million miles to the planet Mars, in order to search for — well, something like us.

Scratching the Surface

In view of the Soviets' fourfold failure to land a successful probe on Mars, NASA took few risks with Viking. In an impressive stroke of engineering genius (and a generous dash of luck), not one but *two* probes were successfully landed on Mars. The fact that every instrument (with the exception of one seismometer) functioned perfectly upon arrival clearly indicates that the Viking crew members knew their technology.

Three types of observations comprised the search for life: (1) photographs; (2) organic analyses of the soil; and (3) the biology package, itself divided into three experiments. The tests operated by this compact laboratory were the gas exchange experiment, the labeled release experiment, and the pyrolitic release experiment.

Scientists had argued that photographs were the only form of evidence that could supply an unequivocally positive determination of the existence of life on Mars. Of all the experiments, cameras required the fewest assumptions about martian life. In fact, they made only one, but it was a whopper — namely, that life would be big enough to see.

The imaging team, in charge of photographic analysis of the surface of Mars, reported nothing extraordinary beyond a rocky desert landscape. No martian lizards sauntered up to nibble on the cameras; no signs of life were reported.

A gas chromatograph-mass spectrometer analyzed the martian soil for the presence of organic compounds. The result, down to its limit of resolution, was bleak: No "carbon-based units" were detected. The organic concentration was therefore less than that on the Moon, one of the deadest rocks around. In fact, the device found even less organic material than would be expected from the influx of carbonaceous chondrites, one of the many types of small, rocky debris floating around the solar system. This finding led several researchers to conclude that organic molecules not only do not exist on the surface of Mars, but they may be actively destroyed. While this is not encouraging news with regard to organic life, it is not definitive evidence of its non-existence. Gilbert Levin, one of the investigators, cautioned that some samples from the Mojave Desert contained as few as 100,000 *E. coli* per gram — and the gas chromatograph-mass spectrometer would have been unable to detect them.

The biological experiments were not much help. The gas exchange experiment involved two stages: a humid mode and a wet mode. (This assumed, of course, that martian life will like water.) In the humid mode, the air inside the chamber containing martian soil was simply humidified; in the wet mode, the soil was saturated. A solution of nutrients, dubbed "chicken soup" by researchers, was then added to the soil sample. The scientists hoped that martian micro-organisms might metabolize the nutrients and give off carbon dioxide gas, as might be expected from Earthly micro-creatures.

The results were startling. Upon humidification of the chamber, a large amount of carbon dioxide and molecular oxygen (O_2) was given off — "large" meaning 15 times the amount expected (or even explainable) by known non-biological processes. Upon saturation, the amount of oxygen quickly fell, as did the carbon dioxide level shortly thereafter. Whatever had caused the response either (a) was allergic to the chicken soup; (b) drowned; or (c) was a short-lived chemical reaction, which reached its peak and subsided. "Everything we see in the gas exchange experiment points towards chemical oxidation," noted Harold Klein, head of Viking's biological team.

Norman Horowitz, designer of the pyrolitic release experiment, claimed that the gas exchange experiment did not detect metabolism, but "the chemical interaction of the martian surface material with water vapor at a pressure that has not been reached on Mars for millions of years." But scientists had known the atmospheric pressure on Mars well before they decided to send an experiment designed to operate at terrestrial atmospheric pressure.

Another of the three biological tests was the labeled-release experiment. In this test, a nutrient containing radioactive carbon-14 was added to the soil. The gases inside the chamber were carefully monitored for radioactivity, which would indicate that something had metabolized the nutrient.

Again the results were startling. As soon as the nutrient was added, the radioactivity in the space above the soil rose sharply. Although the researchers were initially excited by this phenomenon, their spirits soon leveled off along with the radioactivity inside the incubation chamber. Whatever had caused the response was either (a) fond of the nutrient but not of the radioactivity; (b) drowned; or (c) another short-lived chemical reaction of some kind not anticipated in the experimental design. Gilbert Levin, the designer of the labeled release experiment, remarked, "The response that we get, in amplitude and shape, is consistent with the kinds of response that we are used to seeing in terrestrial soil."

Horowitz found "the production of radioactive carbon dioxide understandable" in light of what he refers to as the gas exchange experiment's evidence for peroxides in the martian soil. Ultraviolet radiation beating down on the martian surface may have produced some exotic chemical reactions quite uncommon on Earth. Indeed, according to Vance Oyama, designer of the gas-exchange experiment, "photodissociative reactions" caused by ultraviolet radiation could elegantly explain the results of the biological tests on Mars. The complicated series of reactions he proposes involves several specialized chemical reactions such as catalysis and polymerization. While it is entirely possible — many would say probable — that Oyama is correct, remember that the ultraviolet penetration of the martian atmosphere was known prior to the Viking mission. If these photodissociative properties are as natural as Oyama purports to show, then why were two of the three biological experiments (including Oyama's) designed in such a way that they became useless as life-detection instruments in the presence of "understandable" oxidants?

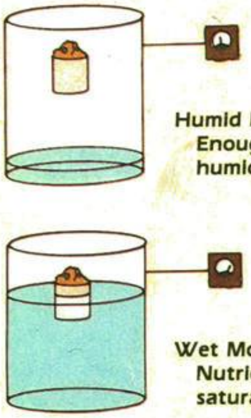
In addition, an important consideration in interpreting the results of the labeled release experiment is the disappearance of the effects upon heating the sample to 160° C for three hours prior to incubation. This part of the test was specifically designed to rule out non-biological interpretations of any positive results. Horowitz, writing in *Scientific American*, noted that while the cessation of apparent metabolic activity upon sterilization is obviously consistent with a biological hypothesis, it is "also consistent with a chemical oxidation in which the oxidizing agent is destroyed or evaporated at relatively low temperatures." Or, as Horowitz wrote earlier in the same article, "A process that is insensitive to heat is . . . likely to be a nonliving chemical reaction, but a process that is sensitive to it could be either living or nonliving."

Finally, consider the pyrolitic release experiment. Of the three biological experiments, this one (designed by Horowitz) was perhaps the most carefully designed to screen out non-biological reactions. This rigorous design renders its results especially interesting, for they are the hardest of all to explain by chemical processes.

The Search for Martian Life

Gas Exchange

Detector monitors changes in gas content of chamber.

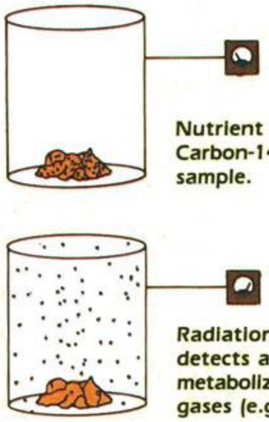


Humid Mode
Enough nutrient to humidify chamber.

Wet Mode
Nutrient saturates sample.

Labeled Release

Detector monitors radiation levels in chamber.

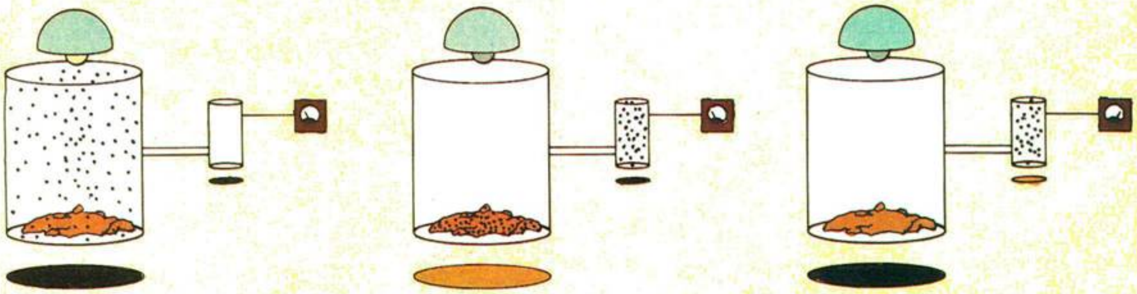


Nutrient laced with Carbon-14 sprayed onto sample.

Radiation counter detects any C-14 metabolized into carbon gases (e.g., CO, CO_2).

Pyrolitic Release

Radiation counter detects organic compounds metabolized with C-14 labeled gas.

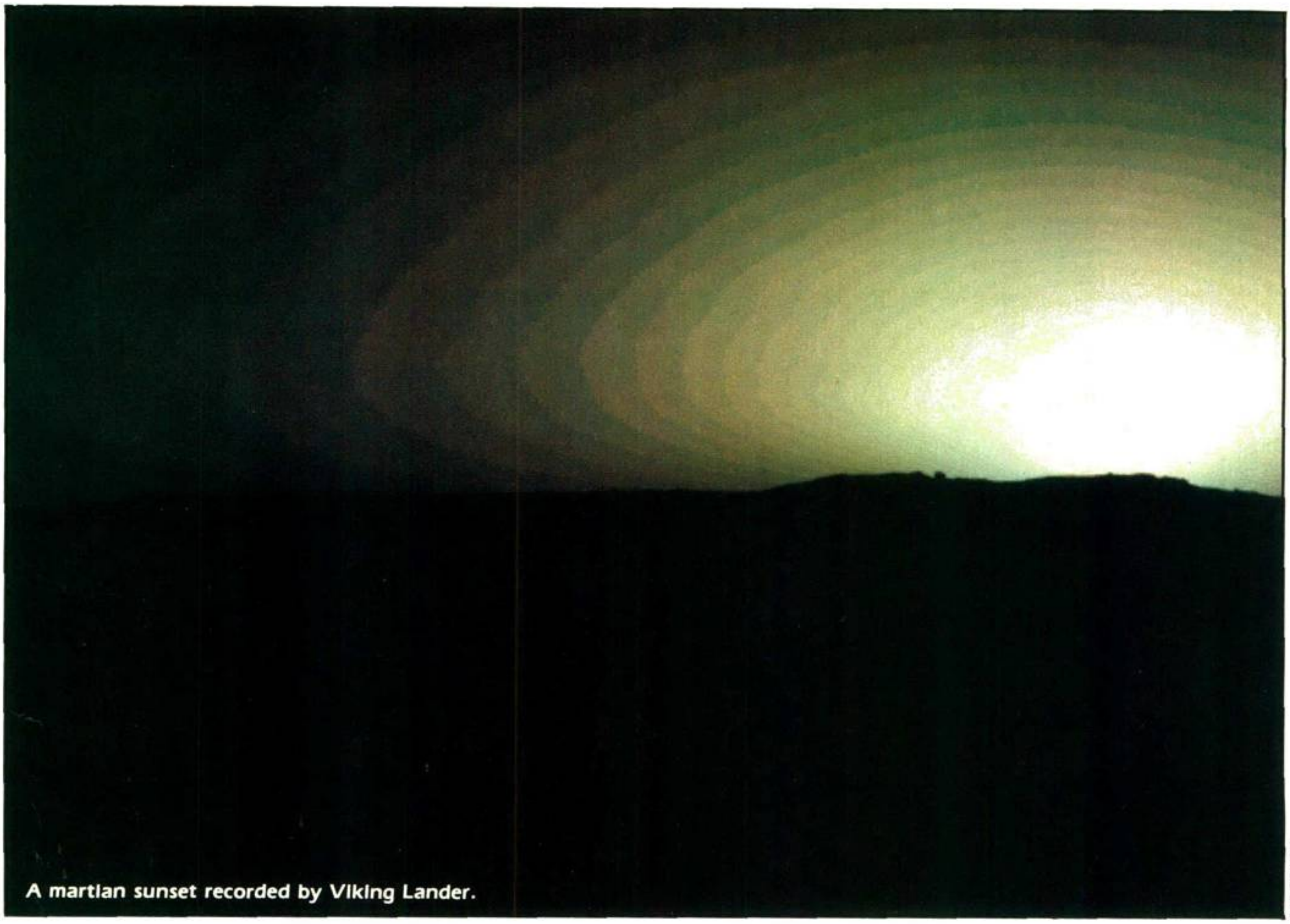


Martian atmosphere spiked with C-14 added to chamber.

Chamber heated, organic compounds vaporized. Gas chromatograph traps organics, non-organics counted for C-14.

Gas chromatograph heated, releases organics. Organic compounds counted for C-14.

NASA/JPL



A martian sunset recorded by Viking Lander.

NASA/JPL

The experiment attempted to measure the *synthesis* of organic matter from the atmosphere, as opposed to decomposition, which the other two tried to detect. In addition, this was the only biological experiment in which any serious attempt was made to perform the tests under conditions of pressure, temperature, and atmospheric composition as close as possible to those on Mars.

A sample of martian soil was sealed into a chamber; simulated martian light was supplied in most of the trials. (The experiment was looking for evidence of a process similar to photosynthesis as it occurs on Earth.) After five days, the lamp was turned off, the atmosphere removed, and the soil analyzed for evidence of the synthesis of organic compounds. In seven out of nine trials, this experiment yielded firmly positive results. Remarkably, one of these positive results was obtained from a sample incubated *in the dark* — indicating that whatever was synthesizing organic matter could do so without light.

The best evidence for a non-biological interpretation of these results is that they are not as sensitive to heat as would be expected of a biological process. In fact, the results of the pyrolitic release experiment are the most difficult of all to account for without postulating some kind of biological mechanism. Horowitz remarks that "until the mystery of the results from the pyrolitic release experiment is solved, a biological explanation will continue to be a remote possibility." Researchers admit somewhat grudgingly that "the mechanism of the synthesis is obscure." And Harold Klein concedes that "the explanation of the pyrolitic release results remains very murky."

Perhaps the most concise synopsis of the results of Viking's search for life is Gerald Soffen's remark, from his book *The Viking Project*: "All the signs suggest that life exists on Mars, but we can't find any bodies!"

In the face of such unexpected — even contradictory — data and the low probability of any further exploration of the martian surface for some time to come, at least by the United States, the only alternative is to make the most of the wealth of information obtained by Viking. How? In the words of Gilbert Levin, "It looks like we'll have to slug it out in the laboratory." While simulation experiments have been carried out by several groups since the Viking results became known, their degree of success in accounting for and duplicating the martian phenomena varies with the individual asked. However, there is little satisfactory evidence to date that the Viking findings will be explained by any simple mechanism of any kind, biological or otherwise.

Since we ourselves fundamentally understand so little about the nature of life, the question of whether the results were caused by something living or non-living is somewhat of a moot point. Norman Horowitz has stated the paradox quite nicely: "Since life is a form of chemistry, how can the two be told apart?"

Although many would have preferred a definite answer for the question of life on Mars, perhaps a good, confusing "maybe" was the best we could have hoped for. There is so much researchers do not understand in what they *did* find that they will be forced to progress tremendously just to make sense out of the data. A definite answer could never have attained the potential for fundamental breakthroughs that Viking's thoroughly ambiguous results has achieved. Attempts to understand the implications of these results could well lead to major breakthroughs in biology.

Viking's "maybe" just might be the most enlightening answer of our generation. As always in dealing with the unknown, the challenge lies in recognition. The keys are there, in the data from the Viking probes. Whether they open any doors is up to us.

Linda J. Strand majors in computer science at the University of Colorado and is a free-lance science writer.

Low Prices, Fast Service, Free Catalog, Giant Selection...And Your Call Is On Us!

Call Toll Free! 800-447-1001 IN CALIF. 800-443-1001

CELESTRON Meade BAUSCH & LOMB Edmund Scientific AccuTrack™ Tele Vue BUSHNELL

- ★ Personal checks, Master Card, Visa gladly accepted.
- ★ FREE shipping when you pay by check!
- ★ FAST shipment—most orders shipped within 24 hours!
- ★ Call TOLL FREE for any reason (not limited to 'orders only')!
- ★ Free expert advice, even if you are buying elsewhere.
- ★ Safe delivery, fully insured, absolutely guaranteed.
- ★ Unconditional money-back satisfaction guarantee!

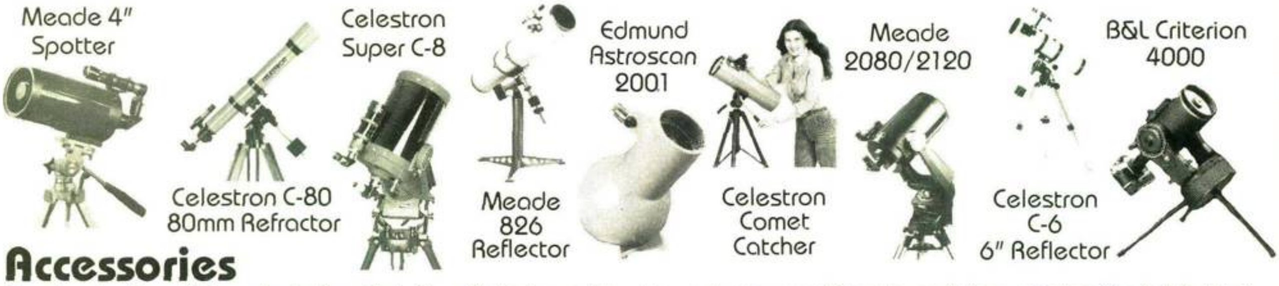
Why Buy From Orion?

Orion is your fast, friendly, professional telescope source. Our experienced staff can answer your questions, make honest and objective recommendations, and speed your order to you pronto.

Our huge FREE catalog is yours for the asking. You'll find hundreds of Celestron, Meade, and other products, plus many of our own unique accessories you'll really like.

Telescopes

We know telescopes, and can give you unbiased advice on any brand or type. Just a few models shown here.


Meade 4" Spotter
Celestron Super C-8
Edmund Astroscan 2001
Meade 2080/2120
B&L Criterion 4000
Celestron C-80 80mm Refractor
Meade 826 Reflector
Celestron Comet Catcher
Celestron C-6 6" Reflector

Accessories

Hundreds of useful products from TeleVue, Celestron, Meade, and our own Orion brand. See catalog for full listing!

Illuminated Reticle Eyepiece
Tele-Vue Eyepieces
Orion Observer's Chair
Giant Binoculars
Lightweight Dew Caps
Lectra-Sox
Handy Eyepiece Case
Giant Finder Scopes
Orion Eyepieces

Electronics

AccuTrack electronic control systems, the largest selection of quality equipment for visual and photographic use.

Declination Motor Drive
FasTrack Dual-Axis Controller
AC/DC Drive Speed Control (3117)
AutoGuide Star Tracker
AccuTrack MiniDrive
Dew Zapper II Dew Eliminator
Digital Quartz Controller

ORION'S UNBEATABLE GUARANTEE

If you are not completely satisfied with your mail-order purchase from Orion, for any reason, just return it in new condition within thirty days after delivery for an immediate refund. You be the judge!

MasterCard VISA

Our 8th Year Of Service

ORION TELESCOPES

P.O. Box 1158-A
Santa Cruz, CA 95061
(408) 476-8715

FREE
FREE
FREE

Free catalog package includes Celestron, Meade and Parks full catalogs and brochures of many other manufacturers, plus discount price lists. The most complete and informative catalog package — yours free. Just write or call.

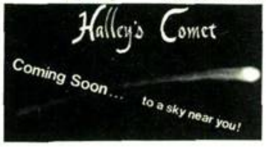
TOMLIN
INDUSTRIES

679 Easy St., Simi Valley, Calif. 93065 / Phone (805) 522-6646
VISIT THE LARGEST AND MOST COMPLETE TELESCOPE SHOWROOM IN THE U.S.
Open to public Mon. thru Fri. 9-6, Sat. 10-4.

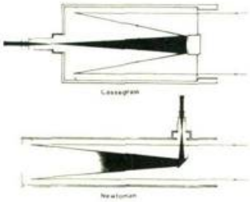
Cotton
Expressions

Cotton Expressions
832 W. Junior Terrace
Chicago, Illinois 60613

Multicolor
T - SHIRTS
Only $7.50
Men's S, M, L, & XL
50% Cotton/50% Polyester

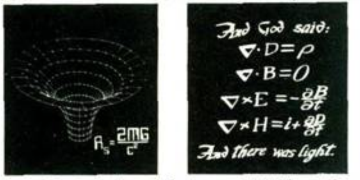

Halley's Comet
Coming Soon...
to a sky near you!

HALLEY'S COMET. White ink on black.
12



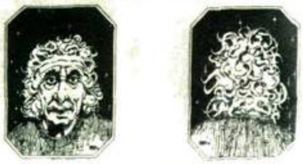
11

PRINTED IN TWO COLORS! Blue shading with black outlining. On lt.-blue shirt only. Also **REFRACTOR** (not shown - style 10).


$R_s=\frac{2MG}{c^2}$
And God said:
$\nabla\cdot D=\rho$
$\nabla\cdot B=0$
$\nabla\times E=-\frac{\partial B}{\partial t}$
$\nabla\times H=i+\frac{\partial D}{\partial t}$
And there was light.

5

Front: Black hole w/ Schwartzchild's radius.
Back: Maxwell's equations of light.



1

DOPPLER-SHIFTED EINSTEIN! Blue front Red back. On white with red trim only.

3

Colors:
Nos.1,10-12 see text
Styles 3 & 5 on red, gold, or lt. blue.
Style 5 also avail. in white ink on black.

Shipping:	via UPS
1 or 2 shirts	1.50
3 or more	2.00

foreign orders add $2.00 extra shipping. Illinois residents please add 6% sales tax. Please send for **FREE** catalog - more designs. Dealer inquiries welcome. © 1982

---

4 OPTICA b/c CATALOGUES

ATM
astro photo
PUBLICATIONS
telescopes

(1) **"Telescopes and Accessories"** over 250 items. (2) **"Astrophotography"** Systems, supplies, special films, chemicals, over 500 items. (3) **"Publications & AVA"** over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) **"ATM"** - goods for the telescope maker, - over 400 items. Each catalog - $1.00; all four - $3.00. Also Receive: **FREE** Astronomical Events Calendar, a wealth of useful information, current discount price list and coupons. **FOREIGN** must add $3.50 for Airmail and send international postal money order or check drawn in U.S.$ on any U.S. bank. Astro equip. & supplies since 1939. Astro Aids, Celestron, Bushnell, Stellar Ventures, OPTICA b/c, Von Werner, B&L, etc.

OPTICA

OPTICA b/c Company
ASTRONOMY DIVISION
4100 MacArthur Blvd., Oakland, Calif. 94619

ASTRO MART

FOR SALE — Refractor tube assembly, special modified Jaegers 4" air-spaced, coated objective, specially designed tube and focusing mechanism. Mint condition, $425. Contact Julius Benton, 1100-A Vincent Road, Warrington, PA 18976. Phone (215) 343-9498 after 6 p.m. Eastern Time.

FOR SALE — Quantum 4" Maksutov with special coatings, complete with mounting and eyepieces, drives, etc. Mint condition, $995. Contact Julius Benton, 1100-A Vincent Road, Warrington, PA 18976. Phone (215) 343-9498 after 6 p.m. Eastern Time.

FOR SALE — ASTRONOMY back issues, complete set from August 1973 through September 1983 in ASTRONOMY slip cases. All in mint condition for discerning library. $275 plus postage. Contact C.M. Schmidt, P.O. Box 531, Midlothian, IL 60445.

ASTRONOMY & SPACE SLIDES

GALAXIES & NEBULAE	50 - $19.50
OBJECTS OF THE SOLAR SYSTEM	20 - $ 8.50
THE SUN/HISTORY OF A STAR	20 - $ 8.50
SPECIAL - ALL slides above in album	100 - $32.95
APOLLO 12, 14, 15, 16, 17	80ea. - $23.95 ea.
EARTH FROM SPACE SPECIAL	60 - $19.95
MARINER 10 - Mercury & Venus	34 - $16.00
SHUTTLE FLIGHTS 1,2,3,4,5,6	20ea. - $ 8.50
BEST VIKING - Mars	20 - $ 9.50
BEST JUPITER Voy. 1 20 - $9.50; Voy. 2	20 - $ 9.50
VOYAGER 1 & 2 JUPITER SPECIAL	100 - $29.95
BEST SATURN Voy. 1 20 - $9.50; Voy. 2	20 - $ 9.50
VOYAGER 2 - SATURN SPECIAL	60 - $19.95
VOY 1 & 2 SATURN with tape	40ea. - $14.95ea.
COLOR MOVIES, Super 8: Jupiter, Saturn, Sun, Sol. Sys., Shuttle, Universe, Apollo 11	$26.95ea
VIDEO TAPES, VHS or BETA	Send for info
OBSERVER'S LOGBOOK - 3-ring binder with 100 observing forms for recording & drawing planets or deep-sky. **Send for info.**	$16.95

Send 37¢ stamp for FREE slide catalog. Outside USA add 20% extra for airmail postage.

ASTRO CARDS
P.O. Box 35, Natrona Heights, PA 15065

1984 OBSERVER'S HANDBOOK
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

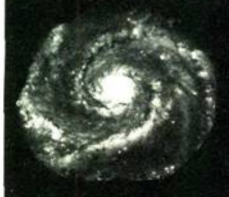
More than twenty astronomers have contributed to produce a comprehensive observer's guide that is unequalled in usefulness for both amateur and professional astronomers. Used annually by thousands of observers, teachers and students, the *Observer's Handbook* has been tested and developed over three-quarters of a century.

The 1984 edition contains 176 pages of information on physical and astronomical data, time, day-by-day predictions for the year, eclipses, occultations and grazes (for Canada and the United States), the planets and their satellites, asteroids, meteors, comets, stars, nebulae, galaxies and radio sources.

Send $8.00 (US) postpaid per copy (cheque or money order) to:

The Royal Astronomical Society of Canada
136 Dupont St., Toronto, Ontario M5R 1V2, Canada

The Midwest's Largest Optical Selection



CELESTRON — complete inventory
UNITRON — complete inventory
EDMUNDS — Astroscan
QUESTAR — 3.5" in stock
MEADE — complete inventory
BINOCULARS — Bushnell, B&L, Pentax, Swift, Celestron
MONSTER BINOCULARS — to 30 x 80

WACK ELECTRONICS
5722 W. North Ave., Milwaukee, WI 53208 (414) 442-3441

ASTRO MART

FOR SALE — Celestron 8, wedge tripod, special coatings, 24mm eyepiece, viewfinder, carrying case. Six months old, mint condition. Contact Rocco Maiolo, 2811 SE Iris St., Stuart, FL 33494. Phone (305) 286-1058.

FOR SALE — 6″ f/8 Dynascope reflector. Equatorial mount, clock drive, rotating rings, two eyepieces (18mm and 9mm Erfle). Shipped in original cartons. In good condition. $250, you pay shipping costs. Contact David Clemens, 251 Perkiomen Ave., Schwenksville, PA 19473. Phone (215) 287-7716.

FOR SALE — 8″ f/6 Meade #791 reflector. Equatorial mount, setting circles, clock drive, 3 eyepieces, Barlow, right-angle finder. Excellent views. $395 plus shipping, or will trade for Meade or Celestron telephoto lens (you pay shipping). Contact Bob Chabane, 810 Pearl, Yankton, SD 57078. Phone (605) 665-8953.

FOR SALE — Unitron 75mm f/16 refractor. Complete with equatorial mount and tripod, slow motion controls, viewfinder, 6 eyepieces, and storage case. Make offer. Contact J.M. Malak, 5019 Farnhurst Rd., Lyndhurst, OH 44124.

FOR TRADE — Astronomy computer programs. Write for my list and please send yours. Contact Steve Clark, P.O. Box 2252, Coeur d'Alene, ID 83814.

FOR SALE — Cave 12½″ f/6 transportable model "D" Newtonian with Cave mount and Dobsonian mount. Accessories negotiable. $1,100. Two giant Erfles, $60 and $80. ASTRONOMY back issues from first issue, $200. All prices negotiable. Contact Richard Hill, 4632 E. 14th St., Tucson, AZ 85711. Phone (602) 325-9820.

METEORITES
AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— PLEASE SEND $1.00 FOR FULL COLOR CATALOG —
Refundable on first order

MEADE
LUMICON
CELESTRON
ACCUTRACK
KALT CORP.
SMITH-VICTOR
STAR ATLASES
TELEVUE OPTICS
DAYSTAR FILTERS
EDMUND SCIENTIFIC
UNIVERSITY OPTICS
SWIFT INSTRUMENTS
ASTRONOMICAL BOOKS
VERNONSCOPE-BRANDON
BUSHNELL OPTICAL CORP.

YOU CANNOT
AFFORD TO BUY A
CELESTRON
Without Calling Us For The
Most Competitive Prices
To Be Found Anywhere.
FAST, FRIENDLY SERVICE
FREE PRICE LIST ON REQUEST

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS

Eugene L. Cisneros
704-706 Charcot Avenue
San Jose, California 95131-2292 USA
Phone: 408-946-4797 daytime
408-923-6800 evening

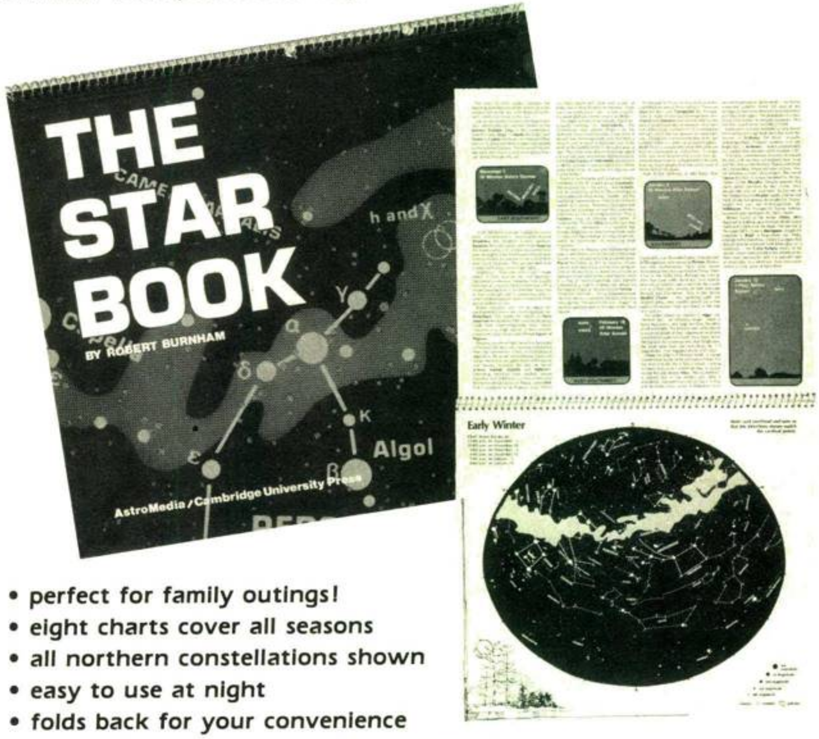
Learn the Constellations with

THE STAR BOOK

from AstroMedia!

Thanks to your requests, we are able to offer ASTRONOMY's popular STAR DOME maps in durable book form. And we've spared no effort to insure that **THE STAR BOOK** will give you years of useful service.

The maps themselves are the same maps you see each month in ASTRONOMY's Eye on the Sky department, reproduced in deep blue and black with white stars for maximum clarity. Constellation names and outlines shown in pale gray; all major stars named; naked-eye and binocular galaxies, clusters, and nebulae are identified. A concise and lucid description of the stars, the constellations, their lore and legends by ASTRONOMY's Robert Burnham accompanies each map.



- perfect for family outings!
- eight charts cover all seasons
- all northern constellations shown
- easy to use at night
- folds back for your convenience
- printed in two colors on thick cardstock
- coated with a durable water-resistant varnish
- heavy-duty wire binding

Preserve your collection of ASTRONOMY — no more torn-up magazines, no more soggy pages — treat yourself to a copy of ***THE STAR BOOK!***

$6.95
postage included

Foreign orders add $1.50

Yes, send me ______ copy(ies) of **THE STAR BOOK** at only **$6.95** each.

Name

Address

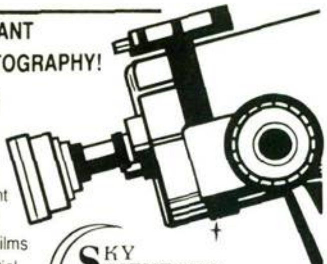
City State Zip

Allow 6-8 weeks for delivery. **AB-9-3**

Send this coupon or a copy to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202 — or use the handy AstroMedia order form bound into this magazine.

INSTANT ASTROPHOTOGRAPHY!

(714) 337-3440



Our Astro-Cameras use nine different Polaroid® color and B&W pack films for instant celestial photography with film speeds from ASA 75 to 20,000!

SKY SCIENTIFIC
28561 Highway 18
PO Box 184
Sky Forest, CA 92385
DEPT. - B

Cameras also have conventional sheet film capability. Send $1 (refunded with first order) for our new illustrated catalog with complete description of our astro cameras and other unique products for photo visual astronomy.

Authorized dealer for CELESTRON and MEADE

ASTROMART

FOR SALE — Three years of *The Planetary Report* (the magazine of the Planetary Society), 1½ years of ASTRONOMY back issues, and miscellaneous astronomy books, all for $50. Contact Joe Bruno, 2839 S. Randolph St., Philadelphia, PA 19148. Phone (215) 339-0543 (evenings).

FOR SALE — 8" Celestron, purchased in 1977, telecompressor, tele-extender, off-axis guider, Tuthill solar filter, 25mm and 40mm Kellner eyepieces, wedge, and 32" Cave Optical pedestal. All for $750, you pay shipping. Contact Chris Quinnert, P.o. Box 1587, Mt. Mesa, Lake Isabella, CA 93240. Phone (619) 379-3071.

FOR SALE — 10" mirror grinding kit, complete, almost new with only a few hours grinding done on it. Asking $90 or best offer. Contact Dave Krier, Rt. 2 Morrill Rd., Mazomanie, WI 53560. Phone (608) 795-2543.

FOR SALE — Dynobyte CP/M business computer. Excellent for astronomy. 64K, 2 disk drives, each holding 1 million bytes. Separate Soroc terminal, 2½ years old. $5200 value, selling for $2000. Write 414 Brightwood Dr., Fayetteville, NC 28303.

FOR SALE — Cave 10" f/6 compact deluxe Newtonian, clock drive, rotating rings, very good condition, asking $750; homemade 6" f/4 rich-field Newtonian, Coulter optics, asking $125; Novak 3.5" diagonal holder (research grade), like new, never used, $5. Contact H. Poolake, RD #1 Almond Rd., Elmer, NJ 08318. Phone (609) 358-8032.

FOR SALE — ASTRONOMY back issues, from first issue through December 1981, $275 or best offer. Contact J. Hutton, 12235 S.E. 62nd St., Bellevue, WA 98006.

FOR SALE — Metrogon lens, reconditioned, original wooden case, filter, anti-dew heaters, government invoice, mounting cone. Ideal patrol or astrographic camera lens. See Mayall's *Skyshooting* for design. $100 plus UPS (recent commercial price $195). Contact John Rollinson, 4101 Riverside Dr., Brunswick, GA 31520.

FOR SALE — 24" Newtonian mirror, about f/3.75, Pyrex, packed and crated. Make an offer. Contact Racine Astronomical Society, Bill Duvall, 518 Emmersten Rd., Racine, WI 53406. Phone (414) 886-5322.

FOR SALE — Towa 80mm, f/15 equatorial refractor; motor drive, five eyepieces, Barlow, prism erector, Sun screen, dust cover, tripod with lighted shelf, $375. Phone Sam Geise, (717) 286-0059.

FOR SALE — ASTRONOMY back issues, February 1976 through December 1982, $70 or best offer; *Sky & Telescope*, January 1978 through December 1982, $50 or best offer; $100 or best offer for all. Sold as sets only. Contact Joe Dal Santo, 236 Hedgerow Dr. Bloomingdale, IL 60108. Phone (312) 980-9290 after 6 p.m. CST.

FOR SALE — *Sky & Telescope* back issues, January 1976 through July 1983, $50. Contact Frank Simon, 1573 Killdeer Dr., Naperville, IL 60565.

STS9 Emblem Features First SPACELAB Mission

YOUNG · SHAW
GARRIOTT · LICHTENBERG
MERBOLD · PARKER
Columbia · Spacelab 1

The Space Shuttle *Columbia* is pictured on this multi-colored embroidered emblem commemorating STS9. NASA's official design shows *Columbia's* payload bay carrying SPACELAB 1, a reusable scientific research laboratory, on the first of many SPACELAB missions. SPACELAB 1 is a joint venture between the European Space Agency (ESA) and NASA.

Great to wear on your jacket or cap!

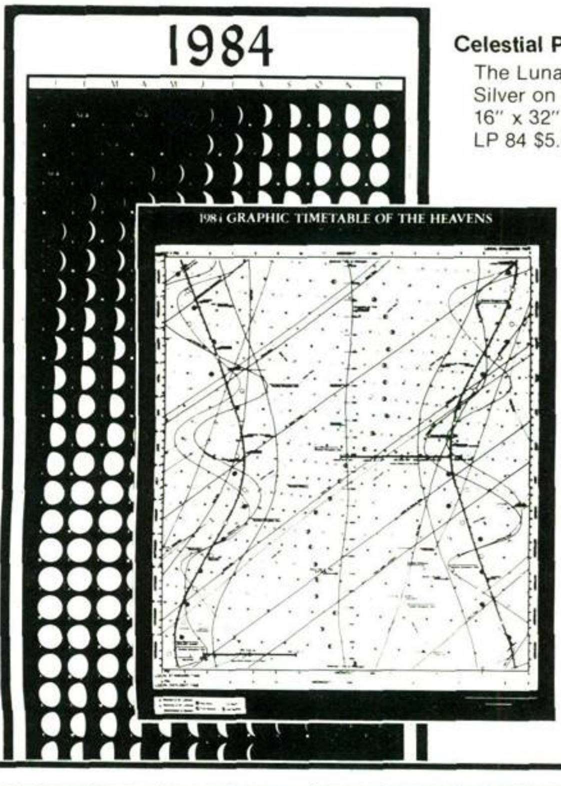
STS9 4" x 4½" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

EXECUTIVE QUALITY TOY
GYROSCOPE
PRECISION MADE WITH FLYWHEEL RUNNING ON BALL BEARINGS.
COMPLETE WITH PULL CORD & INSTRUCTIONS. IDEAL FOR CHILDREN, ADULTS, SCHOOLS & UNIVERSITIES.

PLEASE SEND MONEY ORDER OR VISA/MASTERCARD NUMBER
PRICE £10.95 STERLING, INCLUDING AIRMAIL & PACKAGING
LINAZE LTD., PO BOX 343, MAIDENHEAD, BERKS, SL6 0EJ, ENGLAND.

SKY GRAPHICS
from Scientia, Inc.



Celestial Products Moon Calendar
The Lunar Phase for Each Day
Silver on Blue
16" x 32" Shipped Rolled
LP 84 $5.00 plus $1.50 shipping

Graphic Timetable of the Heavens

- **Over 10,000 Planetary and Lunar Events Charted**
- **Rising, Transit & Setting Times**
- **Eclipses, Conjunctions & Oppositions**
- **Phases of the Moon & Apogee & Perigee**
- **Six Colors with Blue-Black Border**
- **16" x 20" Shipped Rolled**
- **TT84 $5.00 plus $1.50 shipping**

Order both for $12.00 including shipping

Send check to:
Scientia, Inc.
1815 Landrake Road
Baltimore, MD 21204
Phone (301) 828-5494

SALES AND SERVICE

TEXAS NAUTICAL
REPAIR CO

PRODUCTS BY BAUSCH AND LOMB, BUSHNELL, CELESTRON, EDMUND, FUJINON, LEITZ, MEADE, NIKON, ORION, SWIFT, TELE VUE, AND ZEISS

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

COME IN AND COMPARE

Write for the world's finest telescope Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

a symposium on telescope control with micros

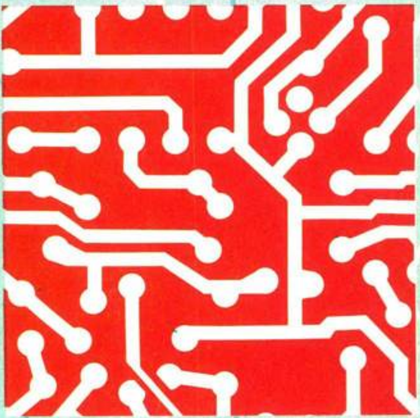
"The best thing you can do," said Bruce Raffert, "is put a stepper motor on the filter wheel. The savings in time is absolutely phenomenal." Bruce Raffert is a young astronomer at Appalachian State University, and he's talking about what a microcomputer has done for that college's small observatory. "I'm my own machinist," he said, "and I wasn't born with a solder iron in my hand, either" — but he's adapted a PET microcomputer to drive a telescope and a photometer, and he's turning out astronomical research.

Bob Fried, a Flagstaff-area amateur astronomer whose interest in astronomy began when "Santa Claus delivered to my son" a 2½-inch telescope back in 1959, and now the owner of Braeside Observatory, controls his homemade photometer with an Apple computer running software written in BASIC. He hadn't brought his equipment. "We thought it was better to leave our equipment on the telescope [for observing an occultation] than to bring it here."

Between July 14 and 16, in the heat of Ohio's midsummer, an extraordinary group of 80-some amateur and professional astronomers met at Fairborn Observatory to discuss the present and future role of microcomputers in astronomy. Jointly sponsored by International Amateur Professional Photoelectric Photometry (the IAPPP) and the American Astronomical Society Special Interest Group for Microcomputer Use in Astronomy (AAS/SIGMUA), the symposium's purpose was to exchange information and experience on the application of microcomputers to photoelectric photometry and telescope control — both the successes and the problems — and to help those people who, working in isolation, had been forced to "re-invent the wheel."

The 30 talks presented during the three-day symposium covered topics as diverse as a large university's fully automated telescope intended for use at the South Pole, Bob Fried's Apple-controlled 16-inch telescope, Bruce Raffert's small college observatory that's run by a Commodore hobby computer, and a microcomputer system rivaling a VAX minicomputer in speed and power that can reduce data taken on the VLA radiotelescope.

"You can use microprocessors even if you don't know anything about them," said Bill Herbst of Van Vleck Observatory, speaking of Wesleyan University's use of computers. "It's very important for people with dedicated telescopes to carry out long-term monitoring," he said. "By doggedly following this star [UX Ori], we've learned something new about it."



Microcomputers clearly have a great future in astronomy.

Microcomputers mean that serious astronomical data-taking is possible for amateur astronomers and small observatories.

Microcomputers will, I am certain, come to act as a "great equalizer" between large observatories, small colleges, and amateur astronomers. For decades big observatories have dominated the acquisition of astronomical data; they will, without a doubt, retain their preeminence in esoteric areas of research. But the ability to precisely control repetitive data-taking with microcomputers means that the "little guys" — amateurs and astronomers at small institutions — will be able to exploit their relatively small telescopes and limited staff for attacking the important but "little" observing programs. Modern astronomy sorely needs their contribution.

Microcomputers clearly have a great future in astronomy. However true, such sweeping generalizations offer little to the average amateur astronomer contemplating, in some vague way, computerizing his or her telescope. I am no expert on computers — although I do use them — and the question I kept asking myself was, "What value does all this have for someone like me?"

Let's begin with the speakers themselves: They were a mixed group, enormously varied in technical sophistication. Some were amateur astronomers with a professional background in electronics who had built excellent working systems; others were amateur astronomers interested in observing variable stars who expressed deep gratitude to one or more technically oriented friends who had helped them put together a computer, telescope, and photometer.

If any one group did dominate, it was astronomers at small institutions — college teachers — attempting to bootstrap themselves and the college telescope into being able to do useful astronomical research. With little or no training in digital electronics and with no significant budget to spend, these people have nonetheless shown themselves capable of building research tools from typical office-size computers and building homebrew computers based on a standard "bus." They were people not "born with a soldering iron in one hand," a class that includes most of us. Aside from having a job teaching astronomy, when it comes to electronics expertise, these professional astronomers might just as well be classed as amateur electronic technicians.

Finally, of course, there were a few astronomers who really knew the digital

Photo by Edwin Lurcott

electronics stuff, who came from big universities or industry, and who had budgets, technical training, and support staff. They described dream systems — systems that would work unattended for long periods of time or powerful, high-speed micro systems for analyzing data from big telescopes.

And the equipment? For the most part, nothing particularly complex. One demonstration device, particularly impressive because of its simplicity, was a VIC-20 that could put a stepper motor through arbitrarily complex routines. The motor was attached to the cassette port of the computer through 2 logic chips and 16 power transistors — the kind of components anybody can buy at Radio Shack. The computer was running FORTH — a computer language that lets the user define the language as he programs in it.

The technically sophisticated amateur astronomers (defined, in my mind, as someone who owns an oscilloscope and knows how to use it) and college teachers discussed homebrew computers based on the S-100 or STD busses and equipped with standard, commercially made I/O, A/D, and stepper motor controller boards. "Leave card-level engineering to the pros," said one, intent on getting on with the photometry. "Not knowing any better," said another, "I just strung 36 feet of ribbon cable from the telescope to the computer in what I suppose would be considered a hostile dome environment." Then he wrapped his computer in blankets to keep it warm enough for winter observing.

To what end was all this work directed? In a nutshell, the goal is *photometry*. If there is any one area of astronomy where the under-24-inch-telescope astronomer — professional or amateur — can compete, it's in systematically measuring the light from stars. In this arena, the light-gathering power of the telescope doesn't matter much, for there are literally thousands of very bright stars begging to have their magnitudes measured. What matters is persistence — the astronomer's willingness to come back and monitor that star over a long period of time.

So — micros are important, and will become more important to astronomy.

But computers are also seductive. In his opening remarks, Douglas Hall of the IAPPP warned, "Computers can do an awful lot," but "I have seen what 'aperture fever' can do to otherwise excellent photometrists, and I am fearful that we will lose astronomers to computers." On the bright side, however, there is "a much wider pool of people out there with an interest in computers, and if we get some of *them* interested in astronomy, we might find we've greatly increased the number of astronomers."

Hall has probably done as much to encourage amateur astronomers to make a useful contribution as any professional astronomer today. With his amateur colleagues, he has co-authored a significant number of papers on spotted RS CVn stars (see "Starspots," ASTRONOMY, February 1983).

"Amateurs," said Dan Caton, speaking for the American Astronomical Society, "can publish professional type results." He went on to speak of the need for closer contact between professionals and amateurs. But because the response might be more than it could handle, he said, the AAS has been reluctant to announce SIGMUA to amateurs. Perhaps that communication function will become one of the roles of the IAPPP.

By providing technical information and meaningful observing programs, the IAPPP already serves as a bridge between amateur and professional astronomers — and it works. Said Bob Wolpert, "We started IAPPP three years ago in Frisco Freddy's with 3 members — and we now have 454 members in 41 countries and 39 states." There's no doubt that microcomputers can serve as an entree for amateurs who want to do something that's important in astronomy — and that something, according to Russ Genet, co-founder of the IAPPP, is photometry. (See "Backyard Photoelectric Photometry," ASTRONOMY, February 1983.)

The symposium got under way Thursday morning with talks on telescope control. Leading off was Frank Melsheimer, President of DFM Engineering, a firm that specializes in custom telescopes. "What *should* a control system do?" he asked. He spoke first of the traditional approach — three motors, each handling one motion function (slewing, tracking, guiding), combined with crude electromechanical methods of keeping the motors from tearing up the drive gear. Then he outlined the modern goals that can be accomplished by having a microcomputer actuate the telescope through stepper or torque motors. First, it speeds up the telescope's motion by computing the optimum rate of acceleration and deceleration, thereby moving the telescope as fast as possible in both axes at once. Second, it means the telescope can perform functions such as scanning or alternating between observing targets. Third, it can slew the telescope to any selected part of the sky when the observer enters in either coordinates or the object's name. Fourth, it should display the current position of the telescope. Fifth — well, the list goes on to include automatic dome control, blind offsets, spectrum widening, compensating for refraction, and so on. The control system DFM manufactures uses two microcomputers, one with 20K and the other with 40K of assembly language programming that totals two man-years of development time. Of course, the DFM system costs more than most small observatories can afford to pay.

But next came Bruce Raffert, of Appalachian State University's Dark Sky Observatory. By comparison, what he had done was very modest — adding two stepper motors to the university's 18-inch US Air Force surplus telescope and controlling them from two Commodore PET computers. At a cost of about $25 each, the two motors had been installed in about six hours time; the computers had simply been available. The system, Raffert said, "relieves the extreme tedium of operating the instrument all night long." A program running in BASIC on one machine controls the telescope, stepping it on and off the program stars, while the other computer logs in data from the photomultiplier tube and stores the data on a floppy diskette. The telescope is "frequently used in an undergraduate student environment," and has apparently survived.

John Oliver followed, speaking on the automatic telescope for the South Pole. The idea is simple: At the South Pole, it's often clear for 60 hours running, so during the long polar night, a telescope could monitor stars for unprecedented periods of time. However, doing astronomy there is difficult: the 12,000-foot elevation and −80°F temperature mean the telescope must operate unattended. The test design is an 80mm aperture refractor that points straight up and observes stars reflected in a mirror. There are no moving parts exposed to the cold, and the telescope is heated inside. It will observe only four stars at an elevation of 47° — the most interesting of which is Gamma² Velorum, a Wolf-Rayet star.

A microcomputer built into the telescope controls everything. It runs a program written in FORTH that monitors all telescope operations, data logging, communication with the outside world, even emergency shutdown in case of computer failure.

On a completely different level, that of the observationally oriented amateur with friends who know about electronics, Bob Fried and Edward Mannery (one of those friends) later described the automated GORT-1 photometer at Braeside Observatory. "It is nearly certain," said Fried, "that the discovery of some surplus $5 stepper motors in a Seattle junk shop had something to do with it." GORT, under the control of the observatory's Apple computer, switches filters and diaphragms and moves automatically from "star and sky" to "sky," as well as displaying and saving all data acquired to floppy diskette for later analysis. Watching the mechanical parts in action (I saw GORT at the IAPPP Symposium in Big Bear, California, a year ago) is impressive — filter and diaphragm wheels move to a new position in less than a second, wait for 10 seconds, then move again. The sheer waste in the usual practice of having an astronomer make those filter changes is, quite possibly, even more impressive than the smooth efficiency of the machine.

Controlling a telescope or a photometer with a computer is, quite obviously, not beyond the capabilities of an amateur astronomer. The question that remains is: When is computerizing a telescope a reasonable thing? To get a handle on this question, let's approach it negatively — we'll define cases where it's *not* reasonable to computerize.

First off, it isn't cheap to computerize a telescope, despite talk of bargain-basement surplus stepper motors. If you include the cost of the computer, the hardware will cost around $500, and that's assuming you can write custom software yourself. But it costs about the same to computerize a rather large telescope — so the cost-effectiveness increases dramatically with increasing telescope size. Computer-controlling a telescope of 4-inch aperture is an interesting engineering challenge, but is not a productive way to spend money.

Second, computerizing serves mainly to improve telescope control efficiency. If you don't need high efficiency, there is little point in applying a computer. But here's where things get weird: You must determine whether you want a "telescope controlled by a computer" or a "data-gathering system," of which the telescope is merely a light-gathering subsystem. If data-gathering efficiency is your main objective, as it would be if you wanted to use an 8-inch telescope to perform photometry continuously throughout the night (while the astronomer slept), and if an 8-inch telescope was big enough to do the job, then the extreme gain in efficiency would justify the cost.

Third, it is pointless to computerize for the sake of computerizing. The reason that the IAPPP and SIGMUA sponsored the symposium in the first place was to help these amateur and professional astronomers achieve a well-defined goal — observing variable stars. But watch that goal! Suppose, for a moment, that you had a system that would point your telescope toward a deep-sky object within 5 seconds, remain pointed at it for 15 seconds, then automatically move to the next object on a pre-entered list. In one 8-hour night you would see 1,440 objects. Okay, it works. Now answer the relevant question: Is that how you want to observe? Yet that same telescope control routine would be perfect for stellar photometry.

I gave my talk right after lunch the first day. One of the greatest difficulties a computer has in controlling a telescope, I proposed, is communicating with the human observer (sleepy and somewhat inattentive after midnight). Since I've been using an Intex Talker digital text-to-speech synthesizer for proofreading my word processor text, I've gotten used to hearing electronic speech on a daily basis. In an observatory, the voice "data link" would often provide better computer-to-human communication than video, where the screen is an unwanted source of light. In order to get the message across to the Symposium, the speech synthesizer read the paper to the human audience. Speech synthesis has interesting possibilities — just as I've become fond of "Vec" Grafix, the little voice in my word processor, I'll bet astronomers working in lonely observatories could find companionship in the talking telescope control systems.

The papers given the second day were, on the average, somewhat more technical. Assuming that you plan to design and build the computer yourself, what is the best way to go about it? Preliminary choices include position sensors and motors that will go on or into the telescope, whether to convert analog photometer signals to digital or use the equipment in pulse-counting mode — and on and on. Planning becomes serious when it gets down to the system bus, whether to use the S-100 common in business computers (defended most eloquently by Dave Dupuy of Virginia Military Institute), the STD bus of industrial designers (offering lots of off-the-shelf "intelligent" boards for instrument control), Q-Bus (which I'd never heard of before), or the low-cost hobbyist's approach with an Apple (for which lots of inexpensive add-ons are available). The bottom line on hardware depends on how much you know (or care to learn) about microcomputers. But you *can't* computerize without learning something — which brings us right back to Doug Hall's concern that astronomy will inevitably lose people to the fascination of computers.

One area where virtually no amount of playing with computers will distract an astronomer from doing astronomy is data reduction. All the 10-second integrations that he's collected must somehow be converted into a format that shows stellar magnitudes at such and such a time, and that, in turn, must be reduced to time of minimum light, period and epoch, or periodogram. Doug Morse discussed the data handling at Braeside Observatory, where the system can search its database and output a set of observations of any star that has been observed with the telescope.

Dan Caton spoke of the next step: a system now under development that will make possible the reduction and analysis of binary star light curves for small colleges and amateur astronomers. Written for the inexpensive Commodore 64 computer, the software he is developing will enable reading and writing data to disk, sophisticated graphic display of light curves, and screen dump to printer. Caton hopes the system will be ready for demonstration in January 1984.

Such meetings are not without their pleasures — on Friday evening, everybody adjourned to Fairborn Observatory for the "Forth [sic] Annual Fairborn Wennie [sic] Roast and Beer Bust," fully a dozen after-dinner speakers, and the groundbreaking ceremony for Fairborn's new One-Meter Telescope. The Observatory, a modest clapboard structure in Genet's backyard, now houses 8-inch and 16-inch reflectors with photometers. The One-Meter telescope, when it is completed, will be one of the largest telescopes in the world used regularly by amateurs for scientific work. Needless to say, it will be fully computerized.

What value does all this talk of computers have for someone like me? First, I doubt that it's worth it to me to install computer control on my own telescope. It wouldn't serve any purpose. Second, it seems that photometry is rapidly becoming feasible for backyard observers who want to do more than just look through their telescopes. Microcomputers will help them enormously. It gives me satisfaction to know that computer control will help other people enjoy astronomy. Third, I have concluded that computer control is a field I want to read up on. You never know when — or what — it might seem feasible to computerize.

— Richard Berry

The Proceedings of the Fourth Annual Fairborn Symposium, "Microcomputers in Astronomy," containing 30 papers presented at this IAPPP symposium, edited by Russell Genet, is available directly from Fairborn Observatory, or may be ordered from AstroMedia for $23.95, postpaid.

the backyard astronomer

auriga

Mercury

Mercury's visibility during December is better than it was in November, but this month's evening elongation still won't present the planet at its best. At highest elevation on the 17th (four days after greatest elongation), Mercury will be just a little over 5° high in azimuth 233° (southwest), 45 minutes after sunset.

In the evening on the 5th, the crescent Moon will pass close to the planet, occulting it for observers in northern Asia and the North Pacific Ocean. During December, Mercury's apparent size will vary between 5.3" of arc across (and 87% lit) on the first to 9.2" and 12% lit on the 26th — probably the last evening you'll be able to locate it during this apparition. On the 31st, Mercury passes through inferior conjunction and joins the rest of the planets in the morning sky.

Venus

Now about a month past its peak elevation in the morning sky, Venus still has enough altitude to assure generally good seeing conditions for telescopic observations.

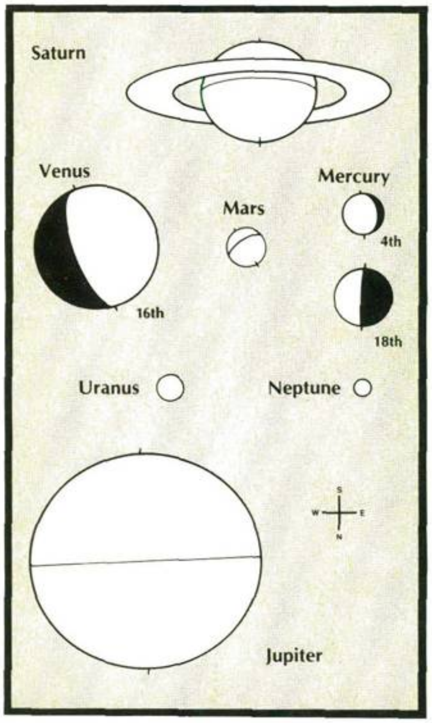
The main event involving Venus this month is its conjunction with Saturn on the 17th. The actual time of conjunction is 10:33 UT; the separation between the two planets will be a little over 9' of arc — thus you should use a medium power eyepiece to group the planets together and reveal their disks clearly. Venus will be 16.8" of arc across and 69% lit, Saturn 15.8". Saturn's rings (measuring 35.6" across) will be tipped 20° to our line of sight.

The two planets will be relatively close for a day or two before and after, so if the weather presents problems on the 17th, try again as soon as you can. This will be one of the year's prettiest celestial events — don't miss it.

John W. Parker used his 5.5-inch f/1.65 Schmidt camera, hypersensitized TP 2415 film, a #92 Wratten filter, and a 30-minute exposure to record the Rosette Nebula in red light and earn this month's "Best Astro-Photo" award. The Rosette is an enormous region of ionized hydrogen surrounding newly-formed stars.

Earth

The Northern Hemisphere's winter solstice occurs at 10:30 UT on the 22nd. This is the moment when the Sun reaches its farthest southern declination and winter begins for us. (In the Southern Hemisphere, of course, the new season is summer.) The vernal equinox lies 89 days ahead — on March 20th at 10:25 UT — and the summer solstice 93 days farther still (June 21st, 5:02 UT).



Moon

The Moon participates in two eclipses this month — a solar on December 4th and a lunar on the 19th/20th. The solar eclipse is annular; its central path slices roughly west to east across equatorial Africa. Almost the entire continent (and southern Europe and parts of northeastern South America) will see a partial eclipse.

Half a lunation later, the Moon will pass just to the north of the Earth's umbra and a deep penumbral eclipse will result. The beginning of this event will be visible from the eastern seaboard of North America, and the entire continent will see the end of it. The Moon enters the penumbra at 23:46 UT on the 19th, reaches mid-eclipse at 1:49 UT on the 20th, and leaves the penumbra at 3:52 UT. At mid-eclipse the Moon will probably display a soft golden color that fades toward dusky grey along its southern limb.

Mars

Growing slowly larger in the eyepiece, Mars continues its eastward trek along the ecliptic — it will pass approximately 4° north of Spica on the 27th. During December, the planet's apparent disk will grow from 4.9" of arc to 5.8" — not much, but each little gain helps you see its features better.

Asteroids

1 Ceres (magnitude 8.8) is moving northeastward out of Capricornus into Aquarius. Its positions:

9th: 22h 01m 57s, −22° 29.8'
19th: 22h 13m 14s, −21° 08.2'

Ceres sets around 9:00 p.m. local time in the middle of December.

2 Pallas (10.5) is moving eastward in the center of Aquila. Its positions:

9th: 19h 39m 42s, +0° 33.1'
19th: 19h 52m 17s, +0° 13.1'

A little more than a month away from conjunction, Pallas sets around 7:30 p.m. local time on the 15th.

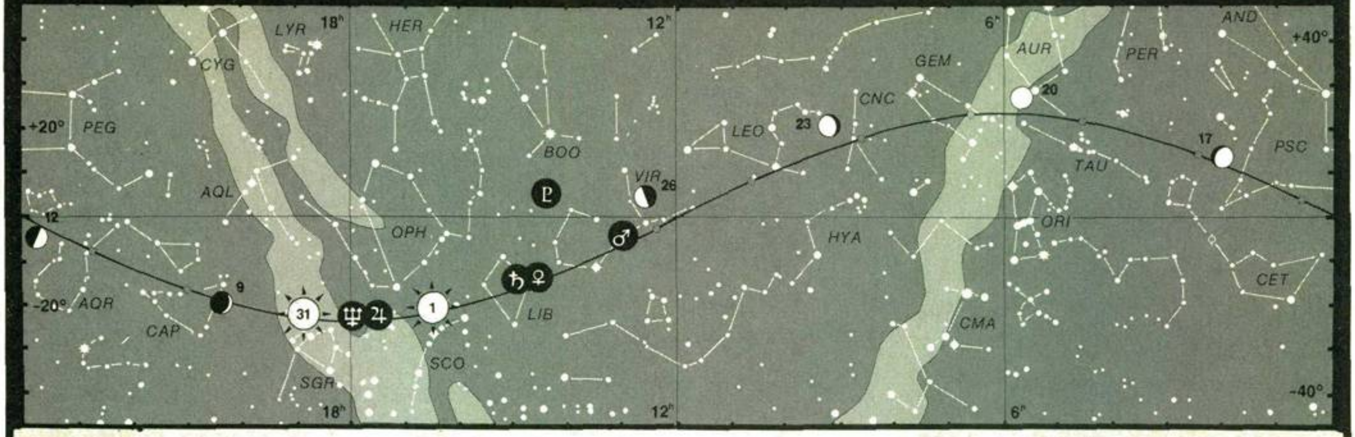
3 Juno (8.5) is moving northeast in Cetus. Between December 12th and 20th, it will be passing to the southeast of the 11th magnitude spiral galaxy NGC-779. Its positions:

9th: 1h 58m 24s, −7° 00.8'
19th: 2h 01m 47s, −6° 09.0'

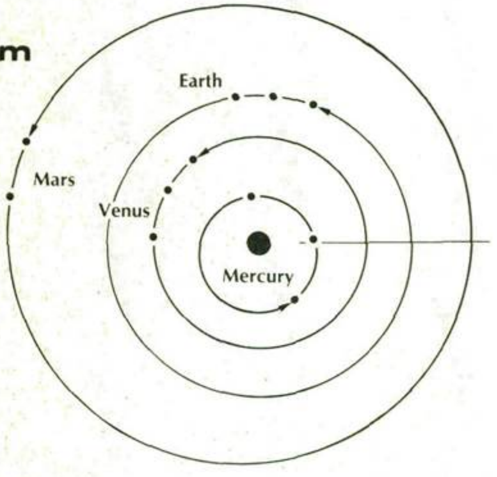
Juno transits around 8:30 p.m. local time on the 15th of the month.

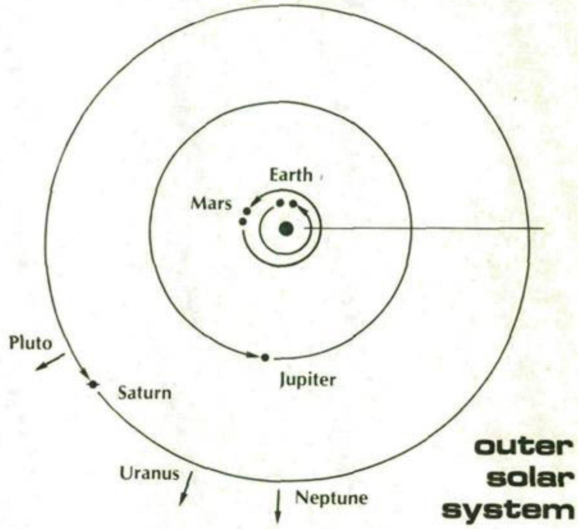
For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

planetary data   december 1983


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
PER
20
CNC
+20°
PEG
LEO
23
17
BOO
TAU
PSC
AQL
♇
VIR
26
12
OPH
ORI
HYA
♂
9
♄ ♀
CET
-20°
AQR
31
♆ ♃
1
LIB
CAP
CMA
SCO
SGR
-40°
18h
12h
6h

inner solar system


Earth
Mars
Venus
Mercury


Earth
Mars
Pluto
Saturn
Jupiter
Uranus
Neptune

outer solar system

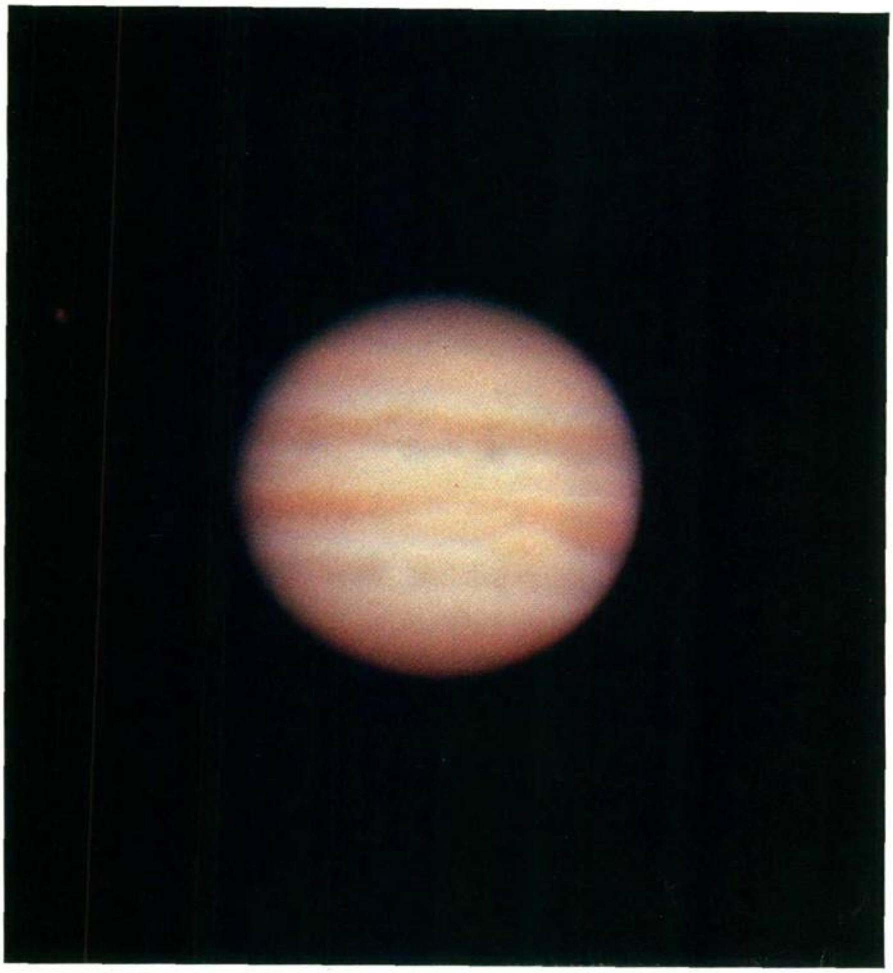
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1983.9)	Dec.
Sun		1	−26.8	32.5′	—	0.99	—	—	248°13.2′	16h 25.8m	−21°40.7′
		15	−26.8	32.6′	—	0.98	—	—	263°27.5′	17h 27.0m	−23°13.5′
		31	−26.8	32.6′	—	0.98	—	—	278°44.1′	18h 38.0m	−23°09.3′
Mercury	☿	1	−0.4	5.3″	87%	1.26	0.43	307°24.6′	264°33.4′	17h 38.0m	−25°40.6′
		15	−0.2	6.8″	58%	0.98	0.35	3°24.6′	282°13.2′	18h 56.9m	−24°34.4′
		31	+2.6	9.9″	1%	0.67	0.31	97°05.7′	278°53.0′	18h 40.6m	−20°40.5′
Venus	♀	10	−3.8	18.9″	66%	0.95	0.72	142°58.4′	213°24.2′	14h 09.7m	−10°35.2′
		31	−3.6	15.4″	74%	1.10	0.72	177°04.3′	238°14.5′	15h 47.9m	−17°43.9′
Mars	♂	15	+1.6	5.3″	92%	1.78	1.66	162°18.8′	194°50.5′	12h 58.9m	− 4°33.7′
Jupiter	♃	15	−1.3	31.4″	100%	6.28	5.29	262°00.4′	261°36.1′	17h 25.5m	−22°51.5′
Saturn	♄	15	+0.8	15.8″	100%	10.56	9.83	218°39.8′	221°52.8′	14h 42.4m	−13°25.1′
Uranus	♅	15	+5.9	3.4″	100%	19.94	18.98	249°31.4′	249°39.9′	16h 34.1m	−21°55.0′
Neptune	♆	15	+8.0	2.3″	100%	31.24	30.26	268°55.4′	268°14.5′	17h 54.4m	−22°16.3′
Pluto	♇	15	+13.8	0.1″	100%	30.43	29.84	209°51.0′	210°53.0′	14h 19.7m	+ 3°37.1′

moon data

New Moon	December 4 at 12:26
First Quarter	December 12 at 13:09
Full Moon	December 20 at 2:00
Last Quarter	December 26 at 18:52
New Moon	January 3 at 5:16
First Quarter	January 11 at 9:48
Apogee: Dec. 11 at 0:33	404,691 km.
Perigee: Dec. 22 at 18:26	364,853 km.

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in The Backyard Astronomer are UT unless noted To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on February 2, then EST for the event is 10 p.m., February 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m, March 4.



Using a 12.5-inch f/6.5 Newtonian outfitted for eyepiece projection — altering the focal ratio to f/123 — Donald C. Parker recorded the subtle bands, belts, and festoons of Jupiter. He used 200 ASA emulsion for the 4.5-second exposure, carefully guiding each second along the way. A jovian moon lies to the left of the planet.

4 Vesta (6.9) lies in eastern Taurus and is moving retrograde. Its positions:

9th: 5h 27m 16s, +18° 29.7′
19th: 5h 16m 08s, +18° 44.9′

At opposition on December 13th, Vesta is visible all night long.

To facilitate plotting their positions in a star atlas, all asteroid coordinates are for the epoch 2000.0.

Jupiter

At conjunction on December 14th, Jupiter is too close to the Sun to be seen.

Saturn

Besides its conjunction with Venus on December 17th (see above under Venus), Saturn will also be occulted by the Moon on the morning of the 29th. This event will be visible west and south of a line that runs toward the southeast from eastern Saskatchewan through central Nebraska, eastern Kansas, southwestern Missouri, northeastern Arkansas, and northeastern Alabama to central Georgia and the Atlantic Ocean. Observers on the line will see Saturn's disk "grazed" by the northern edge of the Moon; those north and east of it will see the Moon just miss the planet.

Since the Moon will be a waning crescent (20% lit), disappearance occurs on the Moon's bright limb. The time of disappearance will vary from around 14:30 UT on the West Coast to 16:24 UT at Miami, Florida. Saturn's reappearance from behind the Moon's dark limb will occur up to 80 minutes after disappearance, depending on how close to the graze line your observing site is (closer makes for a shorter time).

The only problem is sunrise. Even for the West Coast, the time of disappearance is well into morning twilight, and by the time the Moon's west-to-east motion cuts off Saturn for observers in Florida, the Sun will have been up for several hours. Still, with a clear sky free from any substantial haze or cloud, you should be able to watch the event in a telescope. Use low power to locate the Moon, then switch to higher powers; a red filter will darken the sky and increase contrast.

Uranus

Uranus is in conjunction with the Sun on December 2nd; it will be out of sight for almost the whole month. But by the last week of December, try looking for it about 10 minutes of r.a. east, and 4° of declination north, of Antares. Its 6.0 magnitude disk is 3.5″ of arc across.

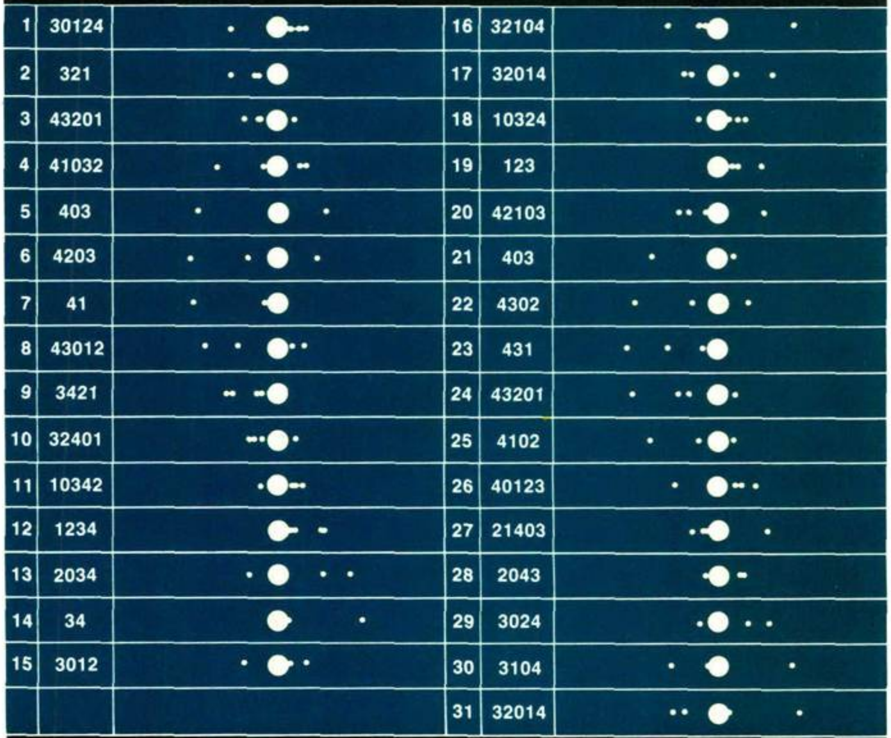
Neptune

Neptune is in conjunction with the Sun on the 21st and will be out of sight all month.

Meteors

The big meteor shower for December

satellites of jupiter **0:00 UT**



1	30124	16	32104
2	321	17	32014
3	43201	18	10324
4	41032	19	123
5	403	20	42103
6	4203	21	403
7	41	22	4302
8	43012	23	431
9	3421	24	43201
10	32401	25	4102
11	10342	26	40123
12	1234	27	21403
13	2034	28	2043
14	34	29	3024
15	3012	30	3104
		31	32014

Jupiter = 0, Io = 1, Europa = Ganymede =3, Callisto =4
(South is at top, matching the view in a telescope)

is the Geminid, which peaks on the 14th and whose radiant lies to the north and west of Castor. Geminids are generally medium-speed and bright; some display colors. The zenithal hourly rate from a dark-sky site is about 60. This year, the Moon will set around 1 to 2 a.m. local time on the 14th and 15th — before then, you'll miss spotting some of the fainter shower members due to the moonlight.

close-up on auriga

Auriga the Charioteer is a bright pentagonal group of stars belonging to the rich winter Milky Way. It contains Capella, the sixth brightest star in the sky, and nice examples of typical galactic deep-sky objects such as bright open clusters and faint nebulae. A few of Auriga's objects can be seen in binoculars, but many require the largest of backyard telescopes and the darkest of skies.

The most enigmatic object in Auriga is the eclipsing variable star **Epsilon** (ε) **Aurigae**, an F-type supergiant star that fluctuates between magnitudes 3.0 and 3.8. It does this in an incredibly long period of 9,883 days — just over 27 years — making its astrophysical nature decidedly tricky to explain. At a distance of around 2,000 light-years, the eclipsing body must be enormous to block the F star's light for so long, but what exactly could it be? Astronomers observe several highly peculiar properties during an eclipse of this star: The eclipsing body seems to be partly transparent because the F-type primary does not completely disappear; the F-star's spectrum remains visible during the eclipse; the primary fades, unusually, without changing color. This suggests that the eclipsing body is probably an enormous flattened ring of gas and dust viewed edge-on, which passes horizontally across the F-star when it begins an eclipse. Currently at minimum light, Epsilon's total eclipse is predicted to end on January 16, 1984; the entire eclipse is due to end on June 25, 1984. (See "Mystery Star," ASTRONOMY, August 1983.)

This unique system lies 3° southwest of Capella, and is one of the "Kids"; the other two are Zeta (ζ) and Eta (η). A pair of binoculars shows both of these stars, which you can use for magnitude comparison with Epsilon. Eta shines at magnitude 3.2, while Zeta is slightly variable from magnitude 3.8 to 3.9. By glancing back and forth between the three stars, you can determine whether Epsilon is closer in brightness to Zeta or to Eta.

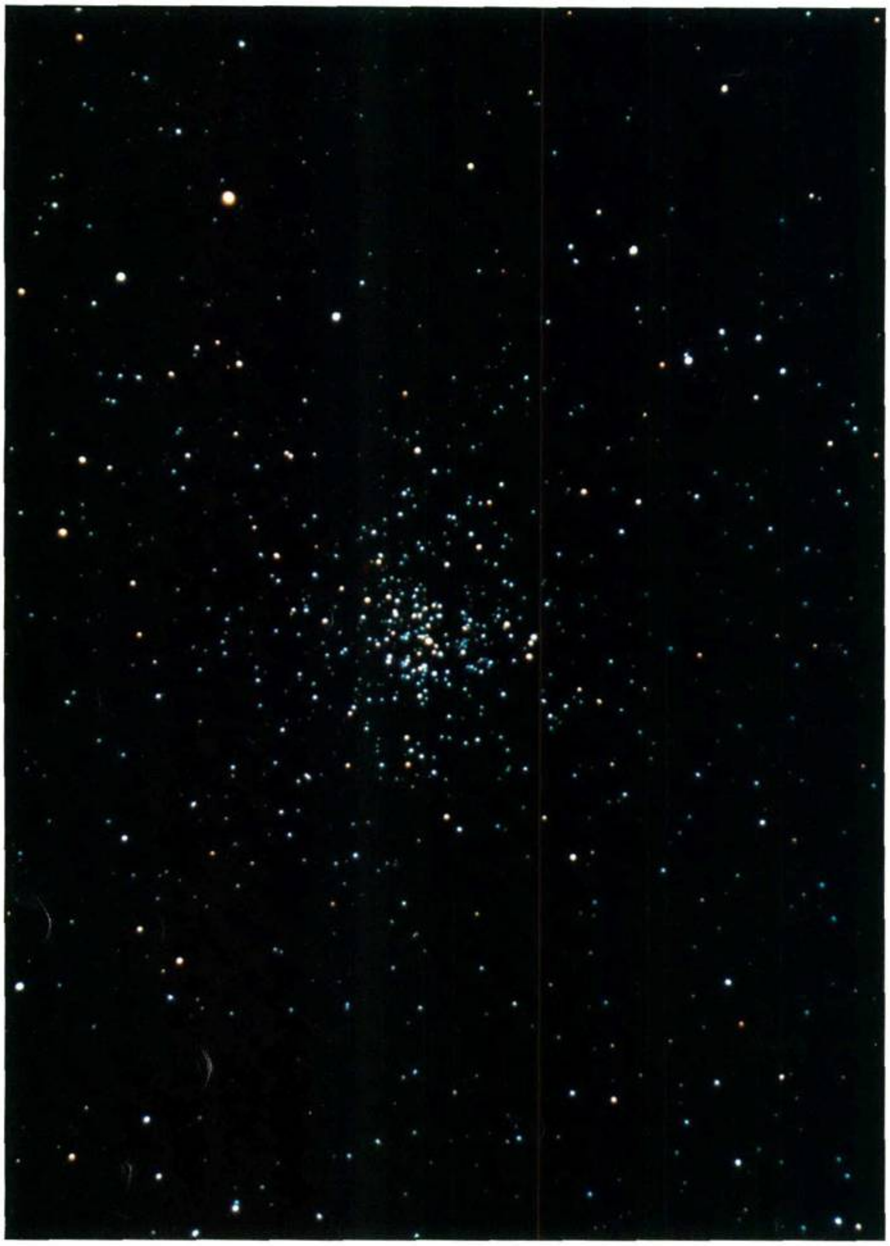
Although it doesn't vary quite as much, **Zeta** (ζ) **Aurigae** is another eclipsing binary — a more normal pair, consisting of a small B7-type blue star and a K4 giant companion. The small hot star is eclipsed by the K-type star once every 2 years and 8 months; the eclipse lasts for 38 days. The range of variance is very small, about magnitude 3.8 to 3.9, and is consequently difficult to detect.

Invisible to the eye, subtle hues of green and pink cover the field in Ronald Royer's exposure of M-42, the Great Nebula in Orion, a large hydrogen cloud. To make the photo, Royer used an 18-inch f/7 Newtonian telescope along with 64 ASA film chilled in a cold camera, and opened the shutter for a 30-minute exposure.

Another variable star in Auriga is **AE Aurigae**, a sixth-magnitude star that occasionally and irregularly varies in energy output. This is an unusual O-type star, probably about 1,600 light-years distant, that glows with the luminosity of around 900 suns. Proper motion studies show that AE Aurigae seems to have traveled from the region of M-42, the Orion Nebula. This star, along with Mu Columbae and 53 Arietis, may be an escaped member of the Orion O and B association of young hot stars. If this is true, AE Aurigae left the group 2.7 million years ago. But why are these three stars traveling away from the M-42 region at such great speeds? Astronomers believe that if they were paired with stars that exploded — went supernova — the sudden loss of mass would disrupt the binary. Suddenly freed from their orbits, these stars would then shoot off at high velocities in random directions.

AE Aurigae illuminates a faint reflection nebula called **IC 405**. This cloud of dust grains measures 18′ across, corresponding to an actual diameter of 9 light-years. The star only recently entered the nebula and is illuminating it by pure accident. It is exceedingly faint, but may be within the grasp of a 6-inch or 8-inch wide-field telescope on a dark night. A 12-inch low-power view shows it as a ghostly arc of milky light.

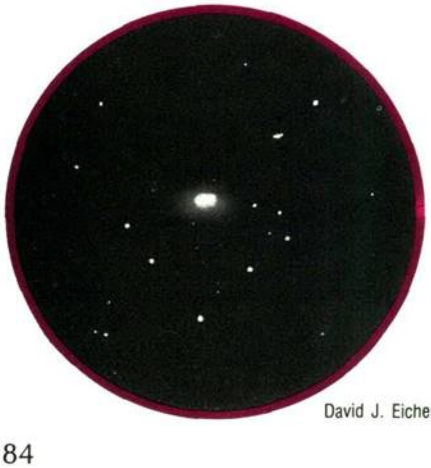
NGC-1931 is another faint reflection nebula, though easier to observe than IC 405 because of its smaller size and higher surface brightness. The nebula measures only 3′ across; a 6-inch telescope at high power shows several faint stars embedded in it. A 12-incher shows that the dust is evenly illuminated and involved in a tiny star cluster; a 16-inch instrument reveals four stars — a miniature Trapezium — amidst nebulosity. The other large swath of reflection nebulosity in the area is **IC 410**, a huge wreath of dust measuring 20′ across. Moderately difficult to observe, this nebulosity is visible in an 8-inch telescope on dark nights. It appears as a large hazy circular glow with two distinct bright portions. If you don't see the nebulosity, you'll certainly see the associated cluster, **NGC-1893**, a large (12′ diameter) group of about 30 stars contained within a triangle of eighth-magnitude stars. A low-power eyepiece coupled with a 2.4-inch refractor shows an eighth-magnitude unresolved haze of light; a 4-inch at moderate magnification reveals a group of tiny stars centered in the triangle.



To record the minute stars composing open cluster M-37 in Auriga, Lee Coombs chose 400 ASA film, pushed to 800 ASA, with his 10-inch f/5 telescope and 15-minute exposure. M-37 is one of a trio of bright Messier star clusters in Auriga; all three are featured in this month's "Close-up" section.

NGC-1931

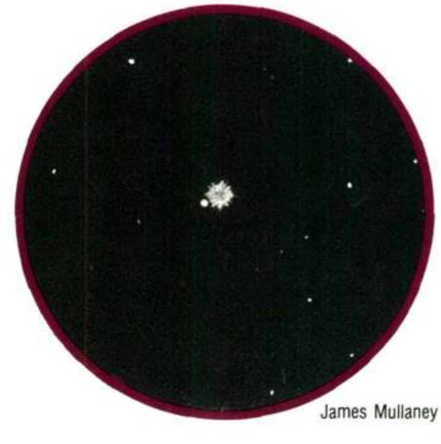
8-inch
100x



David J. Eicher

θAur

8-inch
200x



James Mullaney

Slightly over a degree northeast of NGC-1893 is the rich open cluster **NGC-1907**, a 10th magnitude aggregation of 40 stars of magnitude 10 and fainter. Here 40 stars pack into an area spanning only 5′, resulting in a rich, tight grouping almost resembling a poor globular cluster. A 2.4-inch scope shows a grainy spot of light, while a 5-inch low-power view resolves a few stars. An 8-inch telescope at high power shows a field full of faint stars. In the same low-power field is the bright cluster **M-38** (NGC-1912), a 20′ diameter group of 100 stars of eighth magnitude and fainter. This seventh-magnitude cluster is conspicuous even in binoculars; telescopes must have wide fields of view to contain it. At a distance of 4,200 light-years, the cluster's true diameter is about 25 light-years.

M-37 (NGC-2099) is another of Messier's bright clusters in this part of the sky. It is comparable in size and brightness to M-38 — a half magnitude brighter and one-fourth larger — but contains 150 stars of ninth magnitude and fainter. This makes it noticeably richer and a much more exciting sight in the eyepiece; a 3-inch telescope shows an enormous unresolved haze, very condensed in the center, while a 6-incher shows a sprawling swarm of tiny stars bunched around a red star near the group's center. M-37 makes for a fine view in any instrument, from binoculars to 20-inchers. It lies about 400 light-years farther off than M-38, so is intrinsically larger and brighter.

The last of Messier's Auriga clusters is **M-36** (NGC-1960), a smaller and dimmer cluster than the previous two, although still quite impressive. This sixth-magnitude group of 60 stars measures 12′ in diameter and contains stars of magnitudes 9 to 14. It is much looser than M-37 and M-38, and contains arrangements of two and three stars in pairs and triplets. The most notable of these is the binary star Σ 737. A fairly young open cluster, M-36 lies at a distance of 4,100 light-years, making its actual diameter about 14 light-years.

The single notable planetary nebula in Auriga is **IC 2149**, a 10th magnitude object measuring 10″ across. It is difficult to observe in anything less than a 6-inch scope, and is visible only at high powers, which differentiate the spot of nebulosity from run-of-the-mill background stars.

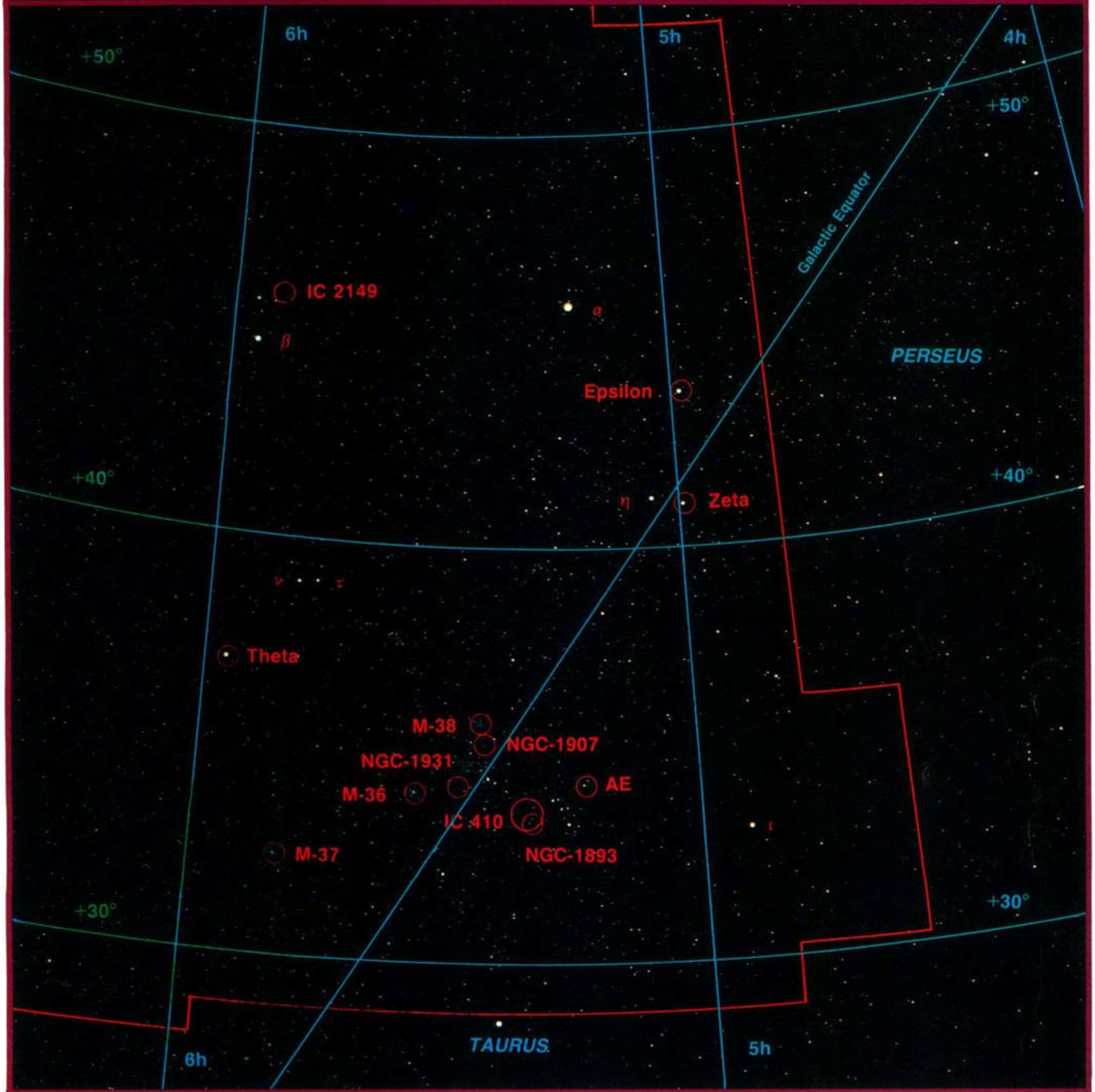
Theta (*θ*) **Aurigae** is a fine double star for small telescopes; its magnitude 3 and 7.5 components are separated by a mere 3.4″ in p.a. 318°. Try high powers on this star when the seeing is crisp and you should handily split the two.

Auriga contains a good selection of bright open star clusters in addition to some rarer types of deep-sky objects much harder to observe. A few nights under the stars with your telescope and star atlas should not only reacquaint you with old friends of the winter sky, but — if sky conditions permit — expose you to some tricky and challenging objects that will develop your skills as a sky watcher.

Photo by Robert Provin and Brad Wallis

auriga

Map by David J. Eicher


6h
5h
4h
+50°
+50°
Galactic Equator
IC 2149
α
β
PERSEUS
Epsilon
+40°
+40°
η
Zeta
ν
τ
Theta
M-38
NGC-1907
NGC-1931
M-36
AE
IC 410
ι
M-37
NGC-1893
+30°
+30°
TAURUS
6h
5h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (2000)	Dec.
Epsilon	EV	3.0-3.8	9,883d	04h 58m	+43°45′	05h 07m	+43°49′
Zeta	EV	3.8-3.9	972d	04h 59m	+41°00′	05h 03m	+41°04′
AE	IV	5.4-6.1	Irr	05h 13m	+34°15′	05h 16m	+34°18′
IC 410	□	14?	20′	05h 19m	+33°28′	05h 23m	+33°31′
NGC-1893	⊙	7.7	12′	05h 19m	+33°21′	05h 23m	+33°24′
NGC-1907	⊙	9.9	5′	05h 25m	+35°17′	05h 28m	+35°19′
M-38	⊙	6.7	20′	05h 25m	+35°48′	05h 29m	+35°50′
NGC-1931	□	13?	3′	05h 28m	+34°13′	05h 32m	+34°15′
M-36	⊙	6.1	12′	05h 33m	+34°07′	05h 36m	+34°09′
M-37	⊙	6.1	20′	05h 49m	+32°33′	05h 52m	+32°34′
IC 2149	■	9.9	10″	05h 53m	+46°07′	05h 57m	+46°07′
Theta	★^{2}	3.0,7.4	3.4″	05h 56m	+37°13′	06h 00m	+37°13′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
RV	*Regular Variable*
SRV	*Semi-Regular Variable*
IV	*Irregular Variable*
EV	*Eclipsing Variable*
⊙	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
0	*Elliptical Galaxy*
§	*Spiral Galaxy*
∮	*Barred Spiral Galaxy*
#	*Peculiar/Irregular Galaxy*

TeleVue™ . . . Even better than you imagined!

Tele Vue 50°
PLÖSSL EYEPIECES
"SHARPEST I'VE EVER USED"

"Used with my 12″ f/7, the Plössls deliver crisp images of the planets. I have the distinct impression that the eyepiece adds no optical errors to the image I'm viewing, and that I am seeing everything the mirror can deliver. This is an impression I've never had with any other eyepiece. Tele Vue Plössls are the sharpest I've ever used."
—From review in August '81 "Astronomy"

New 4 element design improves performance of any telescope. Exceptional contrast and resolution over the entire 50° field, even with fast Dobsonians. Ideal for astrophotography too. Multi-coated. Chromed barrels threaded for filters.
55mm (2″ barrel),
40mm & 32mm (1¼″ barrel)
have widest fields possible for low power viewing. 7.4mm to 32mm models parfocal. 2.5x Barlow is a matched parfocal design. Actually improves eyepiece performance.

TELE VUE 32MM PLÖSSL

PLÖSSLS	
55mm	$150
40mm	70
32mm	70
26mm	55
21mm	55
17mm	55
13mm	55
10.4mm	55
7.4mm	55

BARLOW	
2.5x	55

Tele Vue 65°
WIDE FIELD EYEPIECES
A MAJOR NEW ADVANCE!

New 6-element design (pat. pend.) with a very wide 65° field. Significantly sharper than Erfles and König wide angle eyepieces. Field for field it rivals our Plössls. Almost essential for fast telescopes. Multi-coated.

40mm and 32mm Wide Field models have 2″ barrels. 24mm and 19mm have 1¼″ barrels and are parfocal with our Plössls. "First wide angle eyepiece with snap imaging."
—John Vogt, New York

TELE VUE 24MM WIDE FIELD

WIDE FIELDS	
40mm	$240
32mm	185
24mm	115
19mm	100

Tele Vue 82°
NAGLER EYEPIECES
EXPERIENCE A SPACEWALK!

Patented 7-element design introduces a new dimension in observing. Dramatically more field, sharpness and eye relief than any commercial eyepiece. Multi-coated. Dynamite with Dobsonians.

Naglers fit 1¼″ barrels. 9mm and 13mm also fit 2″ barrels. 9mm and 4.8mm parfocal too.

"With the NAGLER 9, the field is so wide and sharp in my C-8, the telescope seems to 'Get out of the way.' Amazing—a picture window with magnification."
—Pat Walker, Virginia

TELE VUE NAGLER

NAGLERS	
13mm	$200
9mm	175
4.8mm	125

TeleVue

PH. 914 - 354-4262
15-A GREEN HILL LANE, SPRING VALLEY, N.Y. 10977

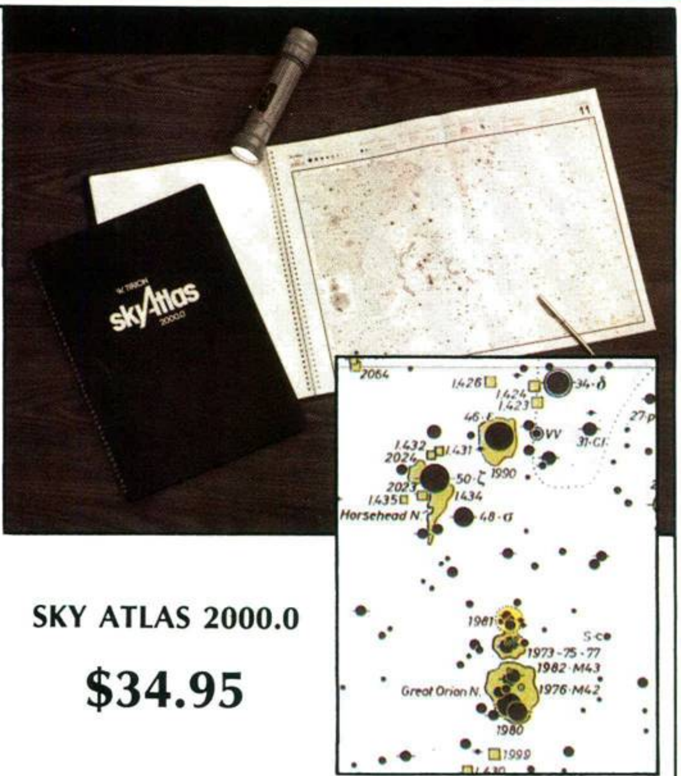
All Tele Vue eyepieces sold with money back guarantee. Shipped postpaid in continental U.S. Residents of N.Y., please add sales tax.

Sky Atlas 2000.0

Join the ranks of knowledgeable amateur astronomers with the **Sky Atlas 2000.0**. Find your way to galaxies, star clusters, and nebulae with ease. These giant star maps are crisp and distinct — and they're beautifully illustrated in color. Even the armchair astronomer will enjoy tracking down favorite nebulae and galaxies and other celestial objects seen in ASTRONOMY.

- 26 charts encompassing both hemispheres
- Each jumbo chart 12½″ x 17½″
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects
- Clearly-defined constellation boundaries
- All Messier objects and thousands of NGC objects
- Celestial coordinates for the year 2000
- Handy reference key on each chart

Also available: **Sky Catalogue 2000.0**. 632 pages of information on over 45,000 stars — including positions, spectral type, and distance. Paperback, **$29.95.**



SKY ATLAS 2000.0

$34.95

U.S. Postage included — Foreign add $2.00

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

SPACE 84

The Calendar of Space Art and Photographs from the Creators of ASTRONOMY Magazine

BRING THE WONDERS OF SPACE TO *YOUR* WORLD!

- *13 exciting new images including:*
  - *— dramatic photos of celestial wonders*
  - *— paintings by today's finest space artists*
  - *— colorful NASA photographs*
- *11⅞'' x 11⅞''*
- *Spiral bound for hanging now, framing later*
- *Important dates in astronomy, celestial events and holidays*
- *Lunar phases shown*
- *Ample space for notes and appointments*

SPACE 84
1 2
3 4 5 6 7 8 9
10 11 12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
JUNE 1984
1 2 3
4 5 6 7 8 9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30
NOVEMBER 1984

GIFT IDEA!
Buy 3 Calendars for $19.95
Get a 4th FREE!

SPACE 84 $6.95

Foreign orders add $1.50

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

SUPERSTAR

RENOWNED CELESTRON OPTICS
GUARANTEED 25 YEARS
HIGH TRANSMISSION COATINGS
FOR MORE BRIGHTNESS
8 X 50 CONVERTIBLE
FINDERSCOPE,
FAST, POWERFUL
M16 Eagle Nebula
Mars
BYERS SIDEREAL WORM DRIVE
FOR OUTSTANDING ACCURACY
(PAT. PENDING)
Orion Nebula
M13
26mm MULTI-COATED
PLÖSSL OCULAR FOR BRIGHT,
CRISP IMAGES
DELUXE LATITUDE ADJUSTER
Total Lunar Eclipse
M33 Spiral Galaxy

The World-Class Super C8—Now At Your Celestron Dealer.

200mm clear aperture, 2000mm effective focal length—in a personal, portable package weighing just 23 pounds, measuring just 17 inches. Fully camera adaptable, f/10 speed, and 791 times the light gathering ability of the human eye. Hand-figured, Celestron Certified optics, and a 25 year limited warranty. Available in your choice of Celestron orange or striking black. The latest generation of the world's best selling modern telescope is available now. Call or contact your Celestron Dealer for a thorough demonstration of this remarkable instrument.

Price increase February 1, 1984!

CELESTRON®
PRECISION OPTICS

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

(Mon-Fri; 8-4:00 Pacific Time; continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578B12, 2835 Columbia St., Torrance CA 90503 (213) 328-9560